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One Winning Favorite at Ascot Park.

POLICE DRIVER SAVES CROWD.

Clings to Seat and Clangs Warning When Team Runs Away.

ACCUSES GERRY SOCIETY.

Baron St. Mart Says Agents Kidnapped His Daughter.

Hoppe Makes Big Run at Billiards.

The Executors of the Estate of Heber R. Bishop certify that this edition of "Investigations and Studies in Jade" consists of one hundred copies printed on American hand-made paper, ninety-eight of which are for presentation and two for copyright.
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INVESTIGATIONS AND STUDIES

IN

JADE

H. R. Bishop

THE BISHOP COLLECTION

New York. Metropolitan museum of art. The Bishop collection.

INVESTIGATIONS AND STUDIES

IN

JADE

VOLUME ONE

NEW YORK
PRIVATELY PRINTED
1906

καὶ μὴν ἀριθμὸν
ἔξοχον σοφισ-
-μάτων
ἐξεῦρον αὐτοῖς
γραμμάτων τε συν-
-θέσεις
μνήμην θ' ἁπάντων
μουσομήτορ' ἐρ-
-γάτιν
THE · DE VINNE · PRESS
IMPRIMATVR

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No. 679

ARTIST'S BRUSH-HOLDER

(*Pi T'ung*)

Ch'ien-lung (1736–95)

Nephrite

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PREFACE

BETWEEN the years 1870 and 1880 I became much interested in Chinese and Japanese art, and soon found the field as wide as the study was fascinating. My interest increased and I extended my researches to metal-work (including arms and armor), porcelain, lacquer, carving in wood and ivory, painting, and not least to the beautiful lapidary work of the Chinese in jade and other hard stones. It is to jade that I wish to confine myself in this book.

I was fortunate in finding some exceptionally fine objects of jade that had been brought from China to New York and Boston. These included many remarkable objects from the loot of the Imperial Summer Palace, near Peking, in 1860, and thus carried with them a certain historic interest. One piece especially, No. 679, an extraordinary work of art, so intensified my interest in jade, and my desire to possess other examples of importance, that I resolved upon a special visit to England and the continent of Europe, where I knew that most of the beautiful pieces had been taken by members of the returning Anglo-French expedition and others.

Many objects had found their way into the shops of dealers in antiquities and "curios," but many were still held by the families of members of the expedition. I found that some pieces had been carried to Frankfort-on-the-Main, Amsterdam, Dresden, Berlin, and Vienna. At St. Petersburg, Moscow, and Constantinople I also obtained some beautiful specimens that had come direct from China.

Having secured all the finest specimens obtainable in Europe that were suitable for my Collection, I went to China, and was fortunate in obtaining there many objects of great interest and of a degree of excellence impossible now to find.

At first my researches were confined to art objects only, and chiefly to those from China and India. Then my interest turned toward the general subject of jade, both mineralogically and archæologically, and I added many specimens of crude material and worked prehistoric objects to my ever-increasing Collection. In this connection I visited Alaska, British Columbia, Oregon, California, and Mexico, and again different parts of Europe.

Early in my studies I became impressed with the meagreness of our knowledge in regard to the nature, origin, and distribution of jade, notwithstanding the learned labors of Frenzel, Von Fellenberg, Arzruni, Damour, Berwerth, Fischer, Meyer, and many others. An interesting "jade question" had arisen, and it seemed to me that the large collection I had made might well be used to settle, or at all events to contribute materially to a settlement of, this question. Having had no experience myself in scientific pursuits, I endeavored to enlist the interest and secure the coöperation of scientists. The mineralogical section was placed in the hands of the eminent mineralogist, Mr. George F. Kunz, and I am happy to state that he was able to secure the assistance of many well-known specialists; and the results of his and their labors, and of my own studies, are now respectfully given to the public in these two volumes. The investigation has extended over several years, and has been most thorough. Readers will find that the work does not dwell on suppositions and theories, and that it is not based on the works of others,—with no intention, however, to

disparage previous investigators and writers, but simply because, with the abundance and variety of the material at our disposal, and the great opportunities presented to us for every form of investigation, it seemed better to restrict ourselves to recording the results of our own studies. The theories advanced and the conclusions reached are not pitted against the theories and conclusions of others, but form an independent contribution to the knowledge of jade. If the results are found valuable, or as interesting as they are to me, I shall be pleased. The work was originally begun and carried on for my own recreation and pleasure. Now that it is completed, it is issued for the instruction and pleasure of the public generally.

Some years ago I had the good fortune to meet Dr. S. W. Bushell of Peking, whom I have always found a most valued friend and learned helper. He was the first to join me in this long, tedious, and at times most discouraging work. However, perseverance overcame all things. In the course of a few years the illustrations, more than four hundred and fifty in number, were finished. Of these twenty are hand-painted in water-colors by a Peking artist. There are thirty-six etchings on copper and twenty-four woodcuts, all executed by the best artists of Paris. For this purpose I sent the jade objects to France and had them again returned to America. Ninety-six objects were illustrated in colored lithography by the two houses of Prang and Forbes of Boston. During the same period the greater part of the pen-and-ink sketches which illustrate the Catalogue were made by Mr. George E. Burr.

Many hundreds of descriptions of the different classes of objects, which also included a study of their structure and hardness by Mr. Kunz, were finished. The article "Jade in China," and the water-color paintings by Li Shih-ch'üan which accompany it, together with a hundred replicas of each of the paintings, were in my possession.

The Collection went on increasing. The slow progress previously made in the investigations of "Jade as a Mineral" changed for the better; new energy had been added by the addition of Dr. Robert Lilley to my staff. At the same time the work on the ever-increasing number of descriptions, illustrations, tables of analysis, and microscopical examinations; specific gravity, compression, and tension tests; studies of hardness, structure, etc., etc., proceeded.

The work is now completed, and I venture to express a hope that it may be found to be of some value as a book of reference.

To the following persons I wish to express most heartily my thanks for all they have done in helping me in this work. Without them it would have been impossible to have arrived at such thorough results.

Dr. STEPHEN W. BUSHELL, C.M.G.

For many years resident at Peking as Physician to H.B.M. Legation; an earnest Sinologue and lover of Chinese Art

For Part II — Jade in China. Also for many interesting descriptions in the Catalogue of the Art Objects; and, in fact, for the great assistance given to me, from first to last, in this work and all my studies of Oriental Art during the past fifteen years.

GEORGE FREDERICK KUNZ, M.A.

Gem Expert and Honorary Special Agent of the U. S. Geological Survey in charge of precious stones

For Part III — Jade as a Mineral. Also for the mineralogical description of almost all of the pieces in the Collection, for many archæological descriptions, and for his bibliographical researches used in the preparation of the work; also for the great interest he has taken in adding new varieties to the Collection.

Dr. ROBERT LILLEY

Who, as editor of Part III, "Jade as a Mineral," has unified the labors of so many collaborators, a task of no small difficulty. Also for his many other labors in connection with this book and my Collection of Oriental Art.

TADAMASA HAYASHI

For his careful attention and useful assistance, in the early days of the Collection, in classifying and cataloguing the many Art Objects.

His heart was full of poetry and he certainly had a love for the beautiful, as some of his comparisons show.

For example, when he described the color of a certain piece of fine jade, it was — "Ah, so beautiful, I can only compare it to the white of the eye of a living Venus!"

In translating into English the Chinese name of a particular class of jadeite, it was — "Bits of moss caught up and held in melting snow."

No wonder such men are happy when occupying themselves in the study of Chinese lapidary work, which excels all others. Such surroundings are conducive to refinement of feeling, create most lovely sentiment, and lead to a kind and tender heart, the source of happiness to one's self and others.

Dr. WILLIAM HALLOCK
Professor of Physics, Columbia University, New York

Who very kindly made all the Specific Gravity determinations (over one thousand), and whose experiments on the Sonorousness of Jade are interestingly set forth by him in the Mineralogical Part.

S. L. PENFIELD, M.A.
Professor of Mineralogy, Yale University

For his valuable article on Jadeite, and for superintending the analytical work of Dr. Percy T. Walden.

Dr. HARRY W. FOOTE
Sheffield Scientific School, Yale University

Who has contributed to the Mineralogical Part valuable sections on the Crystalline Character of Jadeite and the Chemical Character of both Jadeite and Nephrite.

Dr. JOSEPH P. IDDINGS
Professor of Petrology, University of Chicago

Who conducted the Microscopical Investigations, and has contributed to the Mineralogical Part the valuable sections which deal with the Microscopical Petrography of Jade and the Relations of Jadeite and Nephrite.

Professor F. W. CLARKE
Chief Chemist, U. S. Geological Survey

For his studies on Color and the Chemical Constitution of the Mineral. The Chemical Reductions were almost all made by him.

Mr. IRA HARVEY WOOLSON
Adjunct Professor of Engineering, Columbia University

For a series of tests to determine the Compression, Resistance, and Tensile Strength of Jade. His statement of the results and carefully arranged tables form an exceedingly interesting and valuable part of the work.

Mr. LOGAN WALLER PAGE
Formerly Geologist to the Highway Commission of Massachusetts; now Expert in charge of Physical Tests, Division of Chemistry, Department of Agriculture, Washington

For his studies of the Resistance of the Mineral to Impact.

Dr. CHARLES PALACHE
Professor of Petrography, Harvard University

For his services in compiling the tables of all measured and recorded Extinction Angles, and of all the observed Cleavage Angles, and for the great assistance he has rendered generally in the preparation of the Mineralogical Part.

Mr. LOUIS V. PIRSSON
Professor of Petrography, Yale University

For his contribution of a most valuable and suggestive article on the Origin of Jadeite.

Dr. HENRY S. WASHINGTON
Petrographer

For his discussion of the Origin and Distribution of Jade. It is most interesting, original, and suggestive.

Professor L. von JACZEWSKI
Formerly Director of Siberian Geological Section of the Russian Imperial Geological Survey; now Professor of Mineralogy and Geology at the University of Ekaterinoslav, St. Petersburg

For his paper on Siberian Jade and other information regarding it. Also for most of the Siberian specimens.

Dr. A. B. MEYER
Director Königliches Zoologisches und Anthropologisch-Ethnographisches Museum, Dresden

For his very kind suggestions and assistance during my early days in the Study of Jade. From his writings I have obtained much valuable information. I have taken pleasure in quoting him on several occasions.

Dr. MAX BAUER
Mineralogisches Institut der Königliches Universität Marburg, Marburg (Hessen)

For his very kind suggestions and for valuable material and assistance placed at my disposal.

Dr. THOMAS WILSON
Late Curator, Division of Prehistoric Archæology, Smithsonian Institution, U. S. National Museum, Washington.

Dr. JOSEPH EDKINS
of Shanghai.

Professor A. A. DAMOUR
of Paris.

Dr. LUDWIG LEINER
Curator of the Rosgarten Museum, Constance.

Mrs. ZELIA NUTTALL
of the Peabody Museum, Cambridge, Massachusetts

Miss ELIZA R. SCIDMORE

Dr. F. BERWERTH
Mineralogische Abtheilung, Hof Museum, Vienna.

Professor ERNST WEINSCHENK
Professor of Petrography at the Mineralogisches Institut, Munich.

THE FIELD COLUMBIA MUSEUM
Chicago.

SMITHSONIAN INSTITUTION
Washington, D. C.

MUSEUM OF NATURAL HISTORY
New York.

And to others who have rendered me some kind service, and have added valuable and interesting specimens to my Mineralogical and Archæological Collections.

Also to those that have taken such a keen interest in the illustrations, whose names will be found in the List of Plates.

My Collection, now completed, numbers nine hundred specimens, which have been catalogued under the three headings of Mineralogical, Archæological, and Art Objects.

I am anxious to avoid any risk of the Collection being broken up and scattered, and to secure its being kept intact with all its present surroundings and associations. I wish it in future to be available for educational purposes, and that its influence may always be felt in the development of a high standard of refinement and love for the beautiful.

With these aims in view, I have presented the Collection of Jade, with its associate Collection of Hard Stones other than Jade, numbering nearly two hundred pieces, together with a replica of the Louis XV room, their former home in my residence, 881 Fifth Avenue, New York, to the Metropolitan Museum of Art, New York, for the benefit of public instruction.

My intimate associations with this Institution, as one of the members of the Board of Trustees for many years, during which time I have familiarized myself with its thorough organization and good management, satisfy me that there could be no better place for its safety and usefulness.

The "Investigations and Studies in Jade," Volume I, and the Catalogue of the Collection, Volume II, limited to one hundred copies, are intended to be distributed to all nations, in order that, through their public libraries, the scholar and writer may find them available for reference.

Heber R. Bishop.

New York, June, 1902.

PART I

GENERAL INTRODUCTION

No. 762

CHRYSANTHEMUM BOWL

India

Seventeenth Century

Nephrite

JADE

I

GENERAL INTRODUCTION

THE name Jade has been popularly given to several distinct kinds of ornamental stones, although it is scientifically restricted to the minerals *nephrite* and *jadeite*, including in the latter term *chloromelanite*, a variety of jadeite rich in iron, of dark color and high specific gravity. The qualities and distinctive characteristics of these minerals are fully discussed by competent authorities in the Mineralogical Part of the book and need not detain us here. But it should be premised that scientific accuracy is hardly to be expected from the older writers on the subject, who lived in an unscientific age, nor even from the modern Chinese, who rank jade as the most precious of materials for artistic work and for personal decoration, although they know nothing of its chemical constitution or microscopic details.

There is no word of jade in European literature before the discovery of America by Columbus in 1492. The earlier Spanish navigators brought back specimens of green stones which were highly valued by the natives of Central and South America, and were worn by them as badges of rank or as amulets against certain diseases. For this last reason it was given the name of *piedra de hijada*, "hypochondriac or colic stone," which first occurs in the works of Monardes, a physician of Seville, in 1565. He describes it as of emerald-green tint mingled with milky white, the darkest being the best, and dilates on its occult curative properties. He also alludes to its synonym *piedra de los riñones*, or "kidney-stone," and to its reputed value in renal diseases. Hence the name of nephrite, from νεφρός, the kidney, and that of *lapis nephriticus*, which is so frequently used by the older writers.

Sir Walter Raleigh is said to have been the first to bring the stone to England. He always refers to it in his books under the Spanish name of *hijada*.[1]

[1] The Discoverie of the Large, Rich and Bewtiful Empire of Guiana, with a Relation of the Great and Golden City of Manoa (which the Spaniards call El Dorado), etc. Performed in the yeare 1595, by Sir W. Ralegh, Knight, Captaine of her Maiesties Guard, Lo. Warden of the Stanneries, and her Highnesse Lieutenant generall of the Countie of Cornewall. Imprinted at London by Robert Robinson, 1596. (p. 24.)

These Amazones have likewise great store of those plates of gold, which they recover by exchange chiefly for a kinde of greene stones, which the Spaniards call *piedras hijadas*, and we use for spleene stones, and for the disease of the stone we also esteeme them; of these I saw divers in Guiana, and commonly every King or Casique hath one, which their wives for the most part weare, and they esteeme them as great jewels.

The common use of green jade and jade-like minerals for amulets and personal ornaments by the natives of other countries of Southern and Central America is frequently alluded to by other early travellers and writers. In Brazil, Conrad Gesner, who died in 1565, was the first to describe, under the name of *oripendula*, the curious lip-ornaments, now called labrets, which were worn by the natives projecting from their lower lips, perforated for the purpose. Hans Sloane, in his "Natural History of Jamaica, 1725," says that "the Spleenstone, which is very hard, is frequently found on the shores of this Island, among the stones or pebbles common there. They are cut into thin square pieces, and strings being ty'd to holes made in the corners, they are fastned about the arm and thought very much to help in certain Hypochondriac affections. This is the *Piedra Hijada* of the Spaniols and *Pierre de Jade* of the French Authors, who magnify the vertues of it so as to make them incredible. Sir Walter Raleigh first brought some of them to England, giving vast encomiums of them."

The name of jade does not appear in English literature until more than a hundred years after the death of Sir Walter Raleigh, the earliest reference in the "New English Dictionary" being to "Chambers's Cyclopædia" (1727–1741). Dr. J. A. H. Murray, the learned editor of this dictionary, traces out its etymology in a letter to the "Athenæum" of October 20, 1900, which may be quoted here:

The origin of this word (jade) remained a mystery until it was pointed out by Prof. Max Müller in "The Times" of January 15th, 1880, that it was the same word as Spanish *ijada* or *yjada* in *piedra de ijada*, a descriptive appellation given to it in the sixteenth century, in accordance with a belief long entertained that it possessed the virtue of curing pain or disease in the iliac region (*ijada*, late Latin *iliata*). For the same reason Latin writers of the sixteenth and seventeenth centuries called it *lapis nephriticus*, and modern mineralogists *nephrite*. It has not, however, been yet shown how the Spanish *ijada* became *jade* in French and English, nor how the French *jade* is a noun masculine against Spanish *ijada* and Italian *iada*. This is, I suppose, one reason why French etymologists have not accepted Prof. Max Müller's identification, so that in the new "Dictionnaire Général" of Hatzfeld and Darmesteter, as in that of Littré, the derivation of *jade* still stands "origine inconnue." This link in the history of the word can now be supplied. My attention has recently been called to two passages in the English translation of 1657 of the "Letters of Voiture," in which *l'ejade* and *the ejade* are applied to a stone which the context indicated to be jade. On seeing these it was natural to infer that *l'ejade* must be simply taken over from the French original, and that probably the word would there be found to be, as it ought to be, feminine. On turning to the "Lettres de M. Voiture" both expectations have been verified. The word is *l'ejade*, and it is feminine. Mlle. Paulet had sent Voiture a jade stone with the hope that it might cure him of his malady, and in letter XXIII (ed. 1665, p. 47) he says: "Ainsi pour ce coup, l'ejade, a eu pour vous un effet que vous n'attendiez pas d'*elle*." In letter XLII (p. 102) he says: "Je vois bien qu'il me faudra chercher des remedes plus solides que celuy de l'ejade." These are rendered by Davies (ed. 1657, letter XXIII, p. 37): "So that for this time, *l'ejade* hath had for you an effect which you expected not from it." Letter XLII, p. 79: "I perceive there must be found out for me some more substantial remedies than the ejade (misprinted, by splitting the *d*, *ejacle*)." The date of these letters is 1633. They show that *l'ejade* was already in vogue in France as a curative agent; but the word was new and strange, and its actual form uncertain, so that *l'ejade* feminine came to be ignorantly written *le jade* masculine, in which form it appears in the first quotation in the "Dictionnaire Général" in 1667. The anomalous masculine gender of the word in modern French is thus explained. *Le jade* is a bungled writing of *l'ejade*, and the bungle has not only decapitated the word, but changed its gender. In English we have no evidence that *ejade* ever passed beyond the pages of J. Davies's translation of Voiture. Our next quotations for the word are of 1727, also from the French, and in the decapitated form *jade*. An interesting link in the English—and still more in the French—etymology of the word has thus been supplied. There are no doubt many other cases in which the key to an etymological puzzle lies enshrined in a single passage.

The word *jadeite* comes to us directly from the French, having been coined by the eminent chemist Damour in 1863 to distinguish from ordinary nephrite a peculiar kind of jade of granular texture and brilliant tone of coloring, which was found to be the material of some of the most beautiful carved pieces of jade brought to Paris after the sack of the Chinese Summer Palace of Yuan-Ming-Yuan in 1861. It differs, moreover, from nephrite in its greater hardness and higher specific gravity, and especially in its chemical composition. Mr. F. W. Rudler, the Curator of the London School of Mines, who has written several articles on jade, gives a lucid analysis of this valuable memoir, which was presented to the French Academy of Sciences.[1]

[1]A. A. Damour, Comptes Rendus, t. LVI, 1863, p. 861.

M. Damour showed that under the common name of jade at least two distinct minerals had previously been confounded. He therefore proposed to establish a new species under the name of *jadeite*, retaining the old mineralogical term *nephrite* for the typical Oriental *jade*. The chief physical distinction was found in density, that of jadeite being above 3, and rising in some cases to 3.34, while the specific gravity of nephrite was rarely above 3, and generally not more than 2.9. This is the easiest means of distinguishing between the two stones, and is usually, though not perhaps always, decisive. Again, the hardness of jadeite is rather greater than that of nephrite, so that it will scratch the latter; but neither of the minerals is quite so hard as quartz. It is a popular error to suppose that jade is a very hard stone; its prominent characteristic, which confers such value upon it as an implement-yielding material, is not so much its hardness as its toughness—a property due to the closely-felted arrangement of the fine fibres and scales of which it is generally composed. Microscopic characters are not always sufficient to separate the two kinds of jade. Mr. Merrill has usefully pointed out, in his paper "On Nephrite and Jadeite,"[1] that the jadeites are generally more granular or scaly-fibrous in texture, while the nephrites are uniformly fibrous and compact, a distinction sometimes detected by a hand-lens or even by the unaided eye. No safe distinction can be based on color, though it may perhaps be said that jadeite is generally of a more decided green than nephrite. The only absolutely certain means of distinction is found in chemical analysis. The nephrite is a calcium and magnesium silicate, and is now universally regarded as a member of the hornblende group, the white nephrites being varieties of *grammatite* or tremolite, while the green are varieties of *actinolite*. The jadeite is found on analysis to be essentially an aluminum and sodium silicate, perhaps allied to spodumene. Another mineral of dark color and fine-grained texture, often regarded as jade, was separated by Damour as a new species under the name of *chloromelanite*. It is distinguished by its density ranging as high as 3.4 to 3.6.

M. Albert Jacquemart was the first art connoisseur to recognize the intrinsic beauties of jadeite as a material for artistic carved work. He described it in the "Gazette des Beaux Arts," 1854, under the name of *jade impérial*, as a "peerless gem, almost rivalling an uncut emerald when green, and when variegated with green and white, as more effective than the richest of agates."

The early Spanish writers on Mexico and Central America constantly refer to a certain green stone called in the Mexican tongue *chalchihuitl*, which they say was more highly valued by the Mayas and Aztecs than the emerald itself. Bernal Diaz says that among the presents which Montezuma gave to Cortez for the King of Spain there were some of these stones. Montezuma said when handing them over: "To this I will add a few *chalchihuis* of such enormous value that I would not consent to give them to any one save to such a powerful Emperor as yours. Each of these stones is worth two loads of gold." Diaz, in another place, speaking of the skill of the ancient Mexicans in the arts, observes: "After these came the very skilful masters in cutting and polishing precious stones, and the *chalchihuis*, which resemble the emeralds." *Chalchihuitl* is defined by Molina in his "Vocabulario Mexicano" (1571) to signify *esmeralda baja*, or an inferior kind of emerald, and other writers call it *madre de esmeralda;* but it can hardly be the emerald proper, as that was called by the Mexicans *quetzalitzli*, from the *quetzal* (*Trogon resplendens*), and *itzli*, stone. The splendid plumes of this bird, of brilliant metallic green, were worn by the kings of Mexico and Central Mexico as regal insignia. Juan de Torquemada, the Spanish Inquisitor-General,[2] tells us that when a great dignitary died in Mexico, his corpse was richly decorated for burial with gold and plumes of feathers, and they put in his mouth a fine stone resembling emerald, which they call *chalchihuitl*, and which, they say, they place as a heart. The stone, according to another chronicler, if laid upon the tongue of the deceased, will help the soul to pass the seven ordeals before reaching Quetzalcoatl in Heaven. A legend asserts that this great lawgiver and high priest of the ancient Mexicans was miraculously begotten by a *chalchihuitl* placed in the bosom of the goddess Chimalma. The Franciscan monk Bernardino de Sahagun, who came out to Mexico in 1529,[3] describes among the stones the *chalchivites* (Spanish plural of *chalchivitl*) as green, not transparent, and mixed with white, and says that they are much used by the chiefs, who wear them fastened to their wrists by cords, as a sign of rank, and that the lower orders are not allowed to wear them. In another place[4] he alludes to the labret, a chin-ornament (*barbote*) of *chalchihuitl*, set in gold, which is fixed in the beard, the lower lip being slit and the labret worn in the opening, so that it appears to come out of the flesh. The same author, by the way, describes turquoises of varied grade under the names of *teuchivitl* and *chivitl*.

Professor W. P. Blake, in an article on the "Chalchihuitl of the Mexicans,"[5] relates how he found the Navajo Indians in the northern and western portions of New Mexico wearing small ornaments and trinkets of a hard green stone, which they called by the Mexican name, and which they regarded as of great value.

[1] Proc. U. S. Nat. Museum, Vol. XI, 1888, p. 128.
[2] Monarchia Indiana, 1613, Vol. II, p. 521.
[3] Historia de Nueva España, Lib. XI, Cap. viii.
[4] *Ib.*, Lib. VIII, Cap. ix.
[5] American Journal of Sciences and Arts, March, 1858.

This was a variety of turquoise from the vicinity of Santa Fé, and there seems reason to doubt its identification with the true *chalchihuitl* of the ancient Mexicans. The Spanish accounts quoted above seem to point, on the contrary, to the identity of the latter with the emerald-green variety of jadeite.

This is the conclusion of Mr. E. G. Squier, who has done so much to elucidate the early history of Spanish America.[1] He has described an interesting series of carved pieces obtained by him "from the ruins of Ocosingo, in the department of Quesaltenango, Guatemala, on the borders of Chiapas, and not remote from the more famous but hardly less imposing monuments of Palenque." The material was still called *chalchihuitl* by the natives of the district where the objects were dug up, and Mr. Squier's argument that it represents the stone known to their ancestors by the same name is thoroughly convincing. Mr. R. Pumpelly, a competent geologist, after an examination of the same collection, found that the material was exactly similar to specimens of the brilliant green jadeite called *fei-ts'ui* by the Chinese, which had been brought to him from the province of Yunnan in southwestern China. An analysis of one of his specimens, given in Dana's "Mineralogy" (page 293), proves it to be really jadeite. The ancient Mexicans, according to Sahagun, called their most precious green jade *quetzal chalchihuitl*, on account of its resemblance in color to the gorgeous metallic-green plumage of the *quetzal* bird; the Chinese, by a curious coincidence, no doubt accidental, derive the name *fei-ts'ui* from a kingfisher, the peacock-green plumes of which they often use inlaid on jewelry.

In fact, all the jade objects that have been discovered in Mexico and Central America are made of jadeite, and our own Collection shows no exception to this general rule. Among the most celebrated examples are two carved amulets, known as the Humboldt Celt and the Leyden Plate, which have often been figured and described. There is a cast of the Leyden Plate (T) in the Collection. The Humboldt Celt was given to Alexander von Humboldt when he was travelling in Mexico in the year 1804, by Professor Del Rio, and was soon after presented by him to the Berlin Museum, where it is still to be seen in the ethnographical department. It has been illustrated in Lord Kingsborough's "Antiquities of Mexico," Vol. V. A long celt, made of jadeite with a specific gravity of 3.31, of gradually tapering outline and slightly convex sides, it measures 222 millimetres in length, 80 millimetres in width, and averages 34 millimetres in thickness. The Leyden Plate, with flat sides, of similar dimensions but only 5 millimetres in thickness, which is now in the Leyden Museum, was dug up about forty years ago near St. Felipe on the frontiers of Honduras and Guatemala. It appears to have been sawn from the middle of a celt and is bored in two places for suspension, being intended, perhaps, to be worn as a badge of authority. Plaster casts of these two interesting antiquities are exhibited in the museum of the American Antiquarian Society at Worcester, Massachusetts, and they were discussed in a learned paper read before the Society by Dr. P. J. J. Valentini in 1881, which was printed in their Proceedings[2] with the title "Two Mexican Chalchihuitls." But his attempt to decipher the cryptographic inscriptions are not altogether successful. The glyphs are of the same type as those of the hieroglyphic inscription engraved on the back of our interesting jadeite amulet (No. 309), which is said to have been found in Mexico, and the decipherment of which by Dr. Forstermann is also admittedly tentative. The difficulties are due to the misguided zeal of the early Spanish monks, whose efforts to destroy by fire every vestige of native culture recall the barbarous methods of the builder of the Great Wall when he ordered huge bonfires to be made of all Chinese literature. More materials are required for the proper solution of such a problem.

Returning to Europe and its literature, we find that M. Abel-Rémusat, the distinguished French Oriental scholar, was the first to devote special attention to the subject of jade. He wrote a history of the town of Khotan, in Chinese Turkistan, the great centre of the production of jade, compiled from Chinese annals (Paris, 1820), followed by an appendix (pages 117–240) headed "Researches on the mineral called by the Chinese *Yu* and the jasper of the ancients." He shows that the jade stone, called *kash* by the natives of Eastern Turkistan and the Western Mongols, was known as *yeshm* to the Persians and other peoples of Western Asia, and that this word, written *yeshb* in Arabia, is evidently synonymous with the Hebrew *yeshfe* (Exodus xxviii, 20), from which were derived the Greek ἴασπις, the Latin *jaspis*, and the French *jaspe* (jasper). The philological chain is unexceptionable, although it would be difficult to prove his further sug-

[1] On a Collection of Chalchihuitls from Central America: Annals of the Lyceum of Natural History of New York, 1869.
[2] New Series, Vol. I, page 283.

4

No. 645

ROUND BOX

(*Yuan Ho*)

Ch'ien-lung (1736–95)

Nephrite

gestion that jade was really one of the twelve precious stones which studded Aaron's breastplate. Rémusat argues that the jasper of classical times was not what we call jasper now, and that the green jasper which Pliny[1] tells us resembled the emerald, and was worn in the form of amulets throughout the whole East, was in all probability a kind of jade. The chief difficulty in accepting this conclusion is the extreme rarity of jade in collections of works of art of the period. The material was rarely, if ever, used by Greek or Roman artists. The unique celt from Egypt in the Christy Collection at the British Museum is hardly an exception, but it may be conveniently referred to here. It has been described by Mr. C. W. King, the great authority on antique gems, in an article on "A Ceraunia of Jade converted into a Gnostic Talisman."[2] The peculiarity of this implement lies in the fact that it bears upon its two faces Gnostic inscriptions neatly engraved in Greek characters. It is believed that the engraving was executed at Alexandria during the third or fourth century of our era; but the celt itself is, no doubt, of much older date. Supposing it to have been picked up, the fortunate finder would have regarded it, in accordance with early opinion on such objects, as a ceraunia, or thunderbolt,—a holy thing fallen from Jupiter,—on which a mystic formula might appropriately be engraved, with the advantage of making the spell doubly potent. A Chinese celt in the Collection, No. 323, has been similarly inscribed by its finder with a felicitous sentence of four characters, meaning "May the Hua family flourish like Spring!" being deeply incised on one of its surfaces. It is a striking illustration of the identical working of the human mind which has prompted such far-distant people as the ancient Mexicans, Alexandrian Greeks, and Chinese to carve jade celts dug up by them with talismanic inscriptions, as we have no reason to suppose that there could have been any intercourse in those early days to account for such curious coincidences.

But there is no more space for mere speculation here on such subjects. It must suffice to refer those who care to thread their way through the maze of ancient and medieval writers to the industrious and exhaustive monograph of the late Professor Fischer of Freiburg-im-Baden, entitled "Nephrit und Jadeit," the first edition of which was published at Stuttgart in 1875. In this volume quotations from some two hundred authors are ranged in chronological order, forming an almost complete repertory of references; and an alphabetic table of a hundred and fifty synonyms of jade is added, giving the date of the first use of each one in literature. The writer was an enthusiastic exponent of the theory of the exotic origin of both American and European jade, and although this has been negatived by recent discoveries, his work is indispensable to an inquirer into the history of the subject.

The discoveries which started the "jade question" in archæological and ethnological societies throughout Europe were those of jade weapons and implements in the caves of Mentone and several other neolithic deposits in Western Europe, more especially among the relics of the lake-dwellings of Switzerland, followed by the exhibition of thirteen jade implements unearthed by Dr. Schliemann, in 1879, from the ruins of the oldest walled city at Hissarlik. The Swiss implements include all the three varieties of jade. With reference to the pile-dwellings, it is said that nephrite implements are rather characteristic of stations on the eastern lakes (*e.g.* Lake Constance), and jadeite of those on the western lakes (*e.g.* Lake Neuchatel). In France jadeite predominates, confirmed by the examination of the thirteen prehistoric implements from that country in the Collection, only one of which is of nephrite. Dr. Lee's translation of Keller's "Lake Dwellings" (second edition, 1878) contains "Notes on Jadeite and Jade," by Thomas Davies, F.G.S., in the appendix to the first volume. Dr. Munroe, in his admirable work on the "Lake Dwellings of Europe," published in 1890, estimates that up to that time there had been found in all Europe about 500 or 600 worked objects in nephrite, 300 or 400 in jadeite, and about 200 in chloromelanite. From Lake Constance alone he records more than 1000 jade implements, one station on this lake—the station of Maurach—having supplied nearly 500 implements, with 154 chips and sawn fragments, ranging in size from that of a finger-nail to a few inches.

Professor von Fellenberg of Berne, to whom we are indebted for several analyses of Swiss jade implements, referring to the subject in 1869, said, with perfect fairness, that he should hold all of them as derived from the East until mineralogists should show him the mineral in the mountains of Switzerland, or as pebbles in the drift gravels, or in the Nagelflue. Hitherto only two isolated occurrences had been reported in Europe.

[1] Vol. II, Book xxxvii, Ch. viii.

[2] Archæological Journal, 1868, Vol. XXV, p. 103.

The first was of jade pebbles, which had been found toward the end of the eighteenth century in the drifts of Potsdam, near Berlin; and specimens believed to be from this locality are still preserved in the museum at Berlin. The second was an angular, smooth-faced block of a dull-green mineral, as large as a man's hand, which was found many years ago at a depth of several feet, buried in a peat-bog at the alum-works at Schwemsal, near Leipzig. This was at first regarded as a mass of prase or greenish quartz, but its extreme toughness raised a doubt, and on chemical examination it was found to be nephrite. Its occurrence was reported in 1815 by Breithaupt, but Fischer insisted that it must have been a block of Asiatic jade accidentally dropped. It seemed more likely, however, as it occurred in the drift of the North German plain, that it might have been transferred, perhaps ice-borne, from Scandinavia, which is still imperfectly explored geologically. A fragment of the Schwemsal block, so interesting in the history of jade, is exhibited in the Collection as No. 148, together with many specimens recently found *in situ* at Jordansmühl and Reichenstein in Silesia by Mr. G. F. Kunz and others, which help so materially to confirm the theory of the European origin of the Schwemsal boulder.

In 1881, Professor Damour found a pebble or boulder of jadeite at Ouchy, on the Lake of Geneva, and a piece of crude jadeite, described at first as "green jasper," was recorded by him at the same time from Mount Vieso in Piedmont. Some time before, three rolled pieces of nephrite had been found, on separate occasions, in Styria. Two of these are now in the Johanneum at Gratz, and the third is in the museum at Leibnitz. The first two, one of which is represented by Cast B in the Collection, were obtained from the bed of the River Mur, on which Gratz is seated; the third, represented by Cast A, came from that of the River Sann. The occurrence of the Sann nephrite has been critically examined by Dr. A. B. Meyer, of the Dresden Museum, who has been for many years a very strong opponent of the exotic origin of European jades, and has written voluminously in reply to Professor Fischer. The cumulative evidence was getting too strong for Fischer and his followers, and it became difficult to believe that every piece of jade found in Europe was an accidental fragment transferred thither by human agency.

It only remained to find jade actually *in situ* in some European locality, and this soon happened at two localities in Silesia. Herr Traube, of Breslau, obtained from near Jordansmühl, in Silesia, a mineral which he at first took for a hard serpentine, but which turned out on chemical examination to be true nephrite. It occurred in serpentine associated with granulite, and might have been readily overlooked even by a careful observer. Having had his attention thus called to the subject, Traube in 1886 found another occurrence of nephrite in Silesia, this time in the serpentine at the well-known arsenical pyrites mines near Reichenstein. It is true that objects of worked jade had not been recorded from Silesia, but the discovery of the mineral *in situ* at two localities in this country, where its existence was previously unsuspected, shows that its distribution was wider than had been generally supposed.

The following pages will show how successfully the clue furnished by these discoveries has been followed up by Mr. Kunz, and how he found, in 1899, the mammoth block of mottled-green nephrite, weighing 2140 kilos, in a stone-quarry near Jordansmühl, which now stands out so prominently in the Collection, No. 134, an incontestable specimen of European jade.

Referring again to the old controversy, submitted to the International Congress of Prehistoric Anthropology and Archæology held at Brussels in 1872, and summarized in their Proceedings,[1] it was continued in "The Times" during the year 1880, after Schliemann's discoveries at Hissarlik, where he dug up thirteen implements of nephrite, varying in specific gravity from 2.91 to 2.99, one being, he says, of "the rare white jade," the others of "the common green nephrite." They were examined by the geologist of the British Museum, Mr. T. Davies, who has been already referred to. The letters written to "The Times" by Mr. Maskelyne, Professor Rolleston, Professor Max Müller, and Professor Douglas, in support of the probable introduction of the nephrite from Chinese Turkistan, are reprinted in Dr. H. Schliemann's "Ilios," 1880, where they can be conveniently consulted. They were severely criticized by Mr. Westropp in an article "On Jade Implements found in Switzerland,"[2] in which he concludes that there is every reason to believe that the jade must have come from some European locality, and that it was worked on the spot, like all the other stone weapons found in the Swiss lakes, which were made from local sources.

The distant country to which so many authorities were inclined to attribute the ancient supply of European

[1] Comptes Rendus, 1873. [2] Journal of the Anthropological Institute, 1880.

jade was Oriental Turkistan. This has really been in all ages, as we shall see later, the main source of nephrite for China, as well as apparently for Hindustan. The jade of Turkistan, as we shall see described in Part II, is chiefly derived from water-rolled boulders, collected by men wading hand in hand in the rivers of Khotan; but it is also gotten from mines in the mountains south of Khotan and Yarkand, from which these rivers rise. Khotan and several of its subordinate cities are already mentioned as producing jade in the "Annals of the Former Han Dynasty under Wu-Ti" (B. C. 140–87). In A. D. 541 an image of Buddha, sculptured in jade, was sent to China as an offering from Khotan; and in 632 the process of fishing for the material in the rivers of Khotan, as practised down to modern times, is related in the annals of the period. The rivers Karakásh, or "Black Jade," and Yurangkásh, or "White Jade," still bear the names which early Chinese and Arab writers tell us they took from the prevailing colors of the jade pebbles found in their beds, although the Yeshilkásh, or "Green Jade," River, which they also allude to, is not represented in recent maps. The jade-quarries of Khotan, in the valley of the Karakásh River, have often been visited and described by recent travellers; but the mines to the southeast of Yarkand, in the precipitous "Jade Mountains"—Kásh Tág in Turki, Yü Shan in Chinese—appear to be much less known. Most of the pale-green nephrite imported into China in the present day is reported to be brought down on the backs of yaks from these mountains. The jade-mines in this locality were first particularly noticed by Benedict Goes in 1602. A typical example of the jade of this district is the fragment, No. 70, of a weathered boulder from the valley of the Tunga River in the Eastern Pamirs, which was presented to the Collection by Professor von Muschketow, who thinks that the famous monolith in the tomb of Tamerlane at Samarkand, of which we have a fragment, No. 77, may also have come from this locality.

The celebrated Venetian traveller Marco Polo, who passed through Khotan in 1272, says: "There are rivers in this country in which quantities of Jasper and Chalcedony are found." As Colonel Yule, the learned commentator, observes, he refers here doubtless to the semi-precious mineral which was afterward called by us Jade. The next European traveller in these parts was Benedict Goes, who made the overland journey from India to China in 1602–3, an interesting account of which is given in that rare and fascinating book, Yule's "Cathay and the Way Thither,"[1] published by the Hakluyt Society in 1866. Early on his journey Goes met the sister of the King of Kashgar, who was in difficulty: "So he made her an advance of six hundred pieces of gold. She paid him (on their arrival at Yarkand) in pieces of that kind of marble which is so highly esteemed among the Chinese, and which is the most profitable of all investments that one can take to Cathay. *Hiarchan* (Yarkand), the capital of the Kingdom of Cascar (Kashgar), is a mart of much note, both for the great concourse of merchants, and for the variety of wares. There is no article of traffic more valuable, or more generally adopted as an investment for this journey, than lumps of a certain transparent kind of marble which we, from poverty of language, usually call jasper. They carry these to the Emperor of Cathay, attracted by the high prices which he deems it obligatory on his dignity to give; and such pieces as the Emperor does not fancy they are free to dispose of to private individuals. The profit on these transactions is so great that it is thought amply to compensate for all the fatigue and expense of the journey. Out of this marble they fashion a variety of articles, such as vases, and brooches for mantles and girdles, which have an effect of no small magnificence. These marbles, with which the empire is now overflowing, are called by the Chinese Jusce (*yü shih*, or jade stone). There are two kinds of it; the first and more valuable is got out of the river of Cotan, not far from the capital, almost in the same way in which divers fish for gems, and this is usually extracted in pieces almost as big as large flints. The other and inferior kind is excavated from a mountain; the larger masses are split into slabs some two ells broad and are then reduced to a size adapted for carriage. That mountain is some twenty days' journey from the capital (*i.e.* Yarkand) and is called Cansanghi Cascio (*i.e.* Kán sang-i Kásh, Persian for 'Mines of Kásh, or Jade, Stone,' as Colonel Yule shows), that is to say, the Stone Mountain, being very probably the mountain which is so termed in some of the geographical descriptions of this empire. The extraction of these blocks is a work involving immense labour, owing to the hardness of the substance, as well as to the remote and lonely position of the place. They say that the stone is sometimes softened by the application of a blazing fire at the surface. The right of quarrying there is also sold by the King at a high price to some merchants, without whose license no other specu-

[1] Vol. II, p. 55.

lators can dig there during the term of the lease. When a party of workmen goes thither they take a year's provisions always with them, for they do not usually revisit the populated districts at a shorter interval."

The medieval traveller Friar Oderic, who started on his long Asiatic peregrination in April, 1318, has an interesting note on a large bowl of Chinese carved work supposed to be made of jade. His travels are also among those related in Yule's "Cathay and the Way Thither."[1] "The palace in which the great Khan dwells at Cambaluk (Peking) is of great size and splendour. In the midst of the palace is a certain great jar, more than two paces in height, entirely formed of a certain precious stone called *Merdacas*, and so fine, that I was told its price exceeded the value of four great towns. It is all hooped round with gold, and in every corner thereof is a dragon, represented as in act to strike most fiercely, and this jar has also fringes of network of great pearls hanging therefrom, and these fringes are a span in breadth. Into this vessel drink is conveyed from certain conduits from the court of the palace; and beside it are many golden goblets from which those drink who list." The gold mounting, of the same style as that of the bronze supports of the astronomical instruments of the period which have been recently removed from Peking to Berlin, was fatal to the preservation of the jar, which disappeared after the fall of the Mongol dynasty. It was discovered again in the eighteenth century, during the reign of Ch'ien-lung, in the courtyard of a Buddhist temple in the vicinity of the palace, where the ignorant monks were using it for storing salted turnips and cabbages. The emperor purchased it for a few hundred ounces of silver, composed an ode in its honor to be engraved inside, and installed it once more in the palace grounds. It is a large bowl with flat bottom and upright sides, like one of the porcelain bowls (*yü-kang*) which the Chinese use in their gardens for goldfish and lotus flowers, and is boldly carved outside with grotesque monsters and winged horses disporting in sea waves.

China is preëminently the country of jade. It figures among the palladia of the kingdom in their earliest records, and the insignia of the ancient feudal princes of the five grades were all wrought in jade. The ancient "Book of Rites" of the Chou dynasty, a thousand years before Christ, prescribes the articles to be worn on the king's hat and girdle upon various ceremonial occasions, and describes the precious vessels of the state displayed on important occasions and the many ritual vases of the ancestral temple. At the royal funeral a supply of *fan yü*, or "food jade," had to be provided, composed of pounded jade mixed with millet, a piece of jade, called *han yü*, to put in the mouth of the royal corpse, and jade offerings, called *tsêng yü*, in the shape of circular medallions perforated in the middle, were laid in the coffin.

The Chinese, like the ancient Babylonians, distinguish by different colors the objects and elements of nature worship, and they lay down the rule that the jade symbols, woven stuffs, and animal victims, when employed as offerings, should be of appropriate and corresponding tints on each sacrificial occasion. Thus the jade offerings presented in the worship of Heaven are round in form and azure-tinted, those offered to Earth square and clay-yellow; green jade is consecrated to the spirit of the east quarter, red jade to the south, white jade to the west, and black jade to the north; while the strings of beads attached to the mitre-like caps and the girdle pendants of the sacrificial costume used on each occasion must be of corresponding color. The Chinese confess, however, that in the present day it is difficult to find jade of all these colors, even for imperial sacrifices.

Jade is declared by the Chinese to be the solidified essence of the rainbow, which is fashioned for the thunder-god of ancient mythology into bolts, such as are often found on the ground after heavy storms in the shape of celts and arrow-heads; but this is a world-wide myth. The Taoist cult, generally, is riddled with superstitions connected with jade, and it is the favorite food of their immortal genii, as well as the chief ingredient of the longevity beverages prescribed by them for mortal men.

A collection of prehistoric celts was procured by Dr. J. Anderson at T'êng-yueh (Momien), during his journey through the province of Yunnan, the report of which was published at Calcutta in 1871. Several jade celts are figured in the appendix of Dr. Anderson's work among the "Stone and Bronze Implements of Yunnan," and mention is made of their being worn as amulets by the natives, who attribute to them protective virtues against wounds in battle. Dr. Anderson found lapidaries working at jade in Momien, and was told by them that their material was mainly imported from Mogaung in Upper Burma, via Bhamô, and that the best colors were emerald-green and pinkish, or rather lavender, which are those especially character-

[1] Vol. I, p. 130.

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No. 445

FLAT BEAKER

(*Pien Hua Ku*)

K'ang-hsi (1662–1722)

Nephrite

istic of Burmese jadeite. He adds that the large heaps of debris showed that the jade manufactured had been much more extensive in former times. The chief authority on this province, M. Emile Rocher, however, mentions several localities in Yunnan as producing jade.[1] He says: "It is in the West that is found the magnificent jade of which the reputation is established through the Celestial Empire. Shun-ning and Yün-chou are said by the natives to be the places where it is most common. Although in quality it is certainly superior to the southern jade, it ranks below that of T'êng-yueh-t'ing and of the south of Yung-ch'ang. In these last districts it is perhaps not so abundant as in the preceding, but the colour makes it much more appreciated."

The older Chinese authors generally agree in giving this province as one of the principal sources of jade. A mandarin who made an official tour in the reign of K'ang-hsi (1662–1722), for instance, writes:[2] "Among the aborigines of the district of T'êng-yueh there are some who live in trees and make nests in the branches, whose language is unintelligible. The dark-green jade (*pi-yü*) and other precious stones are found in their territory. The savage women make their clothes of the leaves of wild chestnuts, which are large and supple, sewn together, and they look like graceful fairies of Taoist story." This is confirmed by Dr. T. L. Jack, a mining engineer, the latest traveller in those regions, who speaks[3] of the Lolo and Sifan women of the province of Ssu-chuan, on the borders of Tibet, as laden with strings of beads and other ornaments of jade, which there is reason to believe is a production of their mountain fastnesses. Of Momien he says that "jade cutting and jade speculation seem to employ the energies of the greater part of the population."

The boulder section in the Collection, No. 100, was procured from a Peking lapidary as an example of the dark-green jade (*pi-yü*) characteristic of Yunnan. It is a nephrite of peculiarly translucent material, distinguishable by that quality from the *pi-yü* of Manas and other localities in Chinese Turkistan, which is generally more clouded and opaque. There are also in the Collection four pebbles, Nos. 85–88, procured in Shanghai from a Mohammedan dealer in stones, who said that they were found in the bed of the Liu-yang River, in the province of Hunan, and which are of interest as suggestive of another jade locality in China proper.

But jade has not yet actually been seen *in situ* by any competent observer in any of the eighteen provinces of China proper, and it is permissible, meanwhile, to doubt its occurrence and to await more certain evidence. The interior of China is almost unexplored from a geological or mineralogical point of view; even a Chinaman is not allowed to penetrate some of the mountain valleys where jade is most likely to occur, as in the meeting-point, for example, of the three countries of China, Burma, and Tibet. May not this locality be the real source of the pieces of jadeite in the Collection, Nos. 46–57, which are said to have come from Tibet? If so, they could easily have come down the River Irrawaddy to Rangoon, and might have been shipped thence to Europe.

This is the present condition of the "jade question" in the far East. It may be solved at any moment by further discoveries. There may have been ancient quarries which have long since been exhausted; the material of some of the older carved pieces is certainly different in many respects from anything produced now, and seems to point to lost sources of supply.

Burma has always been the country, par excellence, of jadeite, and continues to supply material for the workshops of China, it being chiefly brought to Canton and carved there. The latest account of jade mining in Burma has been given by Dr. J. Nisbet,[4] who lived there many years as Conservator of Forests, etc.:

> Jade-stone, which formed one of the many monopolies of the Burmese Government, and was retained as such by the British, is found in large quantities about the head waters of the Chindwin and the Mogaung tributaries of the Irrawaddy, between the 25th and 26th parallels of latitude. The mine-workers are wild Kachin tribesmen, while the dealers in and users of jade are Chinese merchants; and the exports, averaging some 4000 cwt. a year, valued at nearly £50,000, are almost all shipped to Singapore, for distribution thence to Chinese and Japanese ports. Very small pieces of jade of the purest colour and best quality sometimes fetch fancy prices, while great blocks of inferior quality have little or no value in the connoisseur's eyes.
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> The most celebrated of all jade deposits is a large cliff called the Nantelung, or "difficult of access," overhanging a tributary of the Chindwin River at a place distant about nine days' journey from where the latter receives the waters of the Uru from the north-east. But the guardian spirits there have been ill-disposed for nearly a generation back, in consequence of which work has

[1] La Province Chinoise du Yunnan (Paris, 1879), Vol. II, p. 260.
[2] Report of Journeys in the Provinces of Yunnan and Kueichow (Tien Ch'ien Chi Yu) by Ch'ên Ting, fol. 33.
[3] T. Logan Jack, F. G. S., From Shanghai to Bhamô. Geographical Journal, March, 1902.
[4] Burma under British Rule—and Before, by John Nisbet (2 vols., 1901), Vol. I, pp. 401–403.

long remained in abeyance. The most productive mines at present are those in the country of the Merip Kachin tribe, where some of the largest quarries run up to about fifty yards in length by forty in breadth and twenty in depth. Quarrying operations are confined to the dry season, being undertaken from November till May. Even then the best quarries are generally flooded, which greatly increases the labour of working out the stone. During February and March, when the floor of the quarry or pit can be kept dry for a few hours by means of hard bailing, large fires are lighted with wood at the base of the stone. Despite the tremendous heat evolved, a careful watch is kept to detect the first signs of splitting in the rock. As soon as these become noticeable, the Kachins attack the stone with pickaxes and hammers or insert levers in the cracks, and thus detach portions of the rock. Mortality is high among the jade-workers, as the heat is almost insupportable and the labour severe; but the Kachins are jealous of their sole right to quarry the stone. Burman and Shan brokers arrange prices for the quarried stone between the Kachin miners and the Chinese traders, all payments being made in coined silver. From the quarries the blocks of stone are carried by coolies to Nanyaseik, whence it is transported by water in dug-out canoes to Mogaung, on the railway line leading southwards to Mandalay and Rangoon.

When the British began administering this part of Upper Burma, the Burmese system of annually farming the right of collecting duty on jade was continued, the sale realizing £3,333 for 1887–88. The local chief of the jade-producing tract levied 3*s.* 4*d.* on every load of jade leaving his territory, and also received from the miners ten per cent. of the sums they obtained from the jade purchasers. The headman at Nanyaseik levied 1*s.* 4*d.* on each load, and the farmer of the right of collection for the year claimed an *ad valorem* duty of $33\frac{1}{3}$ per cent. In 1893 this system was slightly altered by extending the period of payment from one to three years.

The blocks of jade are mostly taken to Mandalay to be sawn up. There has always been a good deal of smuggling of stone, to evade payment of the heavy royalty to the farmer of the duty, and new rules have been made to check this.

Jade has been found in many parts of America, both North and South. Prehistoric weapons and implements have been dug up in various directions from mounds and sites of ancient graves; ceremonial relics, carved amulets, and personal ornaments, with inscriptions dating from before the Spanish conquest, have been recovered from the ruins of cities in Mexico and Central America; while the coast Indian tribes of Alaska to-day may still be found grinding jade implements, intended for actual use, fashioned in the lines of the prehistoric celts and scrapers of neolithic ages. Jadeite prevails generally in Mexico and throughout Central America from Guatemala to Costa Rica; nephrite is the material yielded by other parts of North America, as well as by the southern continent, where it is also occasionally found, although more sparingly.

The "jade question," which excited such keen interest in Europe when the Swiss pile-dwellings were first explored, has since reëchoed in America, and it was hoped at first that it would throw an unexpected light on the original migration of the people. But such hopes have been disappointed and the light has turned out to be a mere will-o'-the-wisp. Dr. H. Fischer was again the chief supporter of the migration theory, basing it mainly on the alleged identity of the Mexican and Central American jadeites with those produced in Burma, ignoring the immense distance and difficulty of the overland route by way of Bering Strait, and the improbability of communication by sea in ships, to bring jadeite alone, without any other of the more common Asiatic products, such as rice or grain. Professor F. W. Putnam, however, adopted these views when he presented a series of carved and sawn objects of Central American jadeite, from the Peabody Museum at Cambridge, before the American Antiquarian Society in 1886. Some of the celts had been cut into halves and quarters and drilled with holes and carved, to be worn as "ornaments," and he inferred that this was evidence of the scarcity of the stone, concluding: "Is it not, therefore, reasonable to believe that the stone was brought from Asia in the form of implements by the early migrants to this country, and that as the supply was not kept up, and most likely even its source became unknown, the pieces among the people were cut and recut and preserved as sacred relics of the past, to be, one after the other, finally buried with their owners? Is it not one of the most important facts yet known tending to show that the original possessors of the implements brought them from Asia, and that at least one portion of America was settled by people from that continent?"

Dr. A. B. Meyer, of Dresden, had always argued strongly against the migration theory, and maintained firmly the greater probability of the indigenous origin of the mineral wherever it had been discovered. This has actually been proved to be the case in Alaska and British Columbia, where nephrite implements are extensively distributed along the coast, extending here and there some distance inland; axes, adzes, drills, and other objects being found in Indian graves, in old shell-heaps, and on deserted village sites. Dr. G. M. Dawson, assistant director of the Geological Survey of Canada, who took great interest in the subject, recorded in 1887 the discovery of two small boulders of nephrite, partly worked, in the lower part of the Frazer River

valley, one at Lytton and the other at Yale. The specimens illustrated the method by which the stone was worked. One boulder had been laboriously sawn into rough shape, probably by friction with a thong or piece of wood worked with sharp sand. The stone was cut from opposite sides, and when the cuts were sufficiently deep the median ridge was broken, and the block thus separated into two pieces. The roughly shaped tool thus sawn out was afterward ground and polished. Some other unfinished objects were found in old Indian graves near Lytton, making it certain that the adzes were manufactured there. Dr. Dawson believes the jade boulders to be of indigenous origin, and holds that British Columbia nephrite, so far from having been obtained from Siberia, as Dr. Fischer argued, is an autochthonous mineral produced by the alteration of volcanic material, and that, although not yet found *in situ*, it will be discovered among the highly altered volcanic series of the carboniferous and triassic strata.

In Alaska nephrite has been really discovered *in situ* by Lieutenant G. M. Stoney, of the United States navy, who was told by the natives of the coast that the material was obtained from certain mountains inland, which he finally succeeded in reaching. The locality, now known as the Jade Mountain, is situated north of the Kowak River, about one hundred and fifty miles above its mouth. Lieutenant Stoney brought down and presented to the National Museum at Washington a number of specimens, of which a selection is figured by Mr. T. Wilson in the "Report of the United States National Museum" for 1896, on Plate 38, page 456. The collection has been critically studied by Professor F. W. Clarke and Mr. G. P. Merrill, the former showing by his analyses that it is pure nephrite, while the microscopic investigations of the latter prove that it is not to be distinguished structurally or optically from the nephrite of Siberia or New Zealand. These authorities, in fact, confess that their experience has made them sceptical of the possibility of distinguishing, by means of thin sections under the microscope, between nephrites from various sources, and they sum up the question in these words:

> To our own minds sufficient assurance that the widely scattered jadeite and nephrite objects were derived from many independent sources and possess no value whatever in the work of tracing the migration and intercommunication of races lies in the fact that these substances are comparatively common constituents of metamorphic rocks, and hence liable to be found anywhere where these rocks occur. Their presence is as meaningless as would be the finding of a piece of graphite. The natives required a hard, tough substance capable of receiving and retaining a sharp edge and polish, and took it wherever it was to be found.

There are mineral specimens in the Collection from the State of Washington, in the United States, from the Fraser River and the Yukon district in Canada, and from Alaska, including two of sage-green color from the Jade Mountain, one of which has been analyzed by Professor Clarke. Also a long and varied selection of aboriginal implements and weapons, of which thirteen belong to British Columbia and forty-four to Alaska and the coast of the Bering Sea.

Dr. Thomas Wilson, Curator of Prehistoric Archæology, United States National Museum, in his report just quoted, after supporting strongly the indigenous theory, concludes, nevertheless: "It is not possible to determine this 'jade question' positively or absolutely. We do not as yet (1898) possess sufficient knowledge to solve it finally. Whatever may be at present determined is subject to a reversal by a discovery which may be made at any time in the future. If a jadeite mountain should be found in Mexico or Central America, as a nephrite mountain has been in Alaska, it would settle the question at once, but until a ledge or quarry of jadeite shall be found in America the question must be left in abeyance. The discovery of the place of origin of jadeite in America may never be found, and consequently the question may never be absolutely solved."

While America gave us, through its Spanish invaders, the word "jade," and Asia has furnished us with the finest examples of the stone worked into ornamental forms, we may turn to the islands of the Pacific Ocean between the two continents for some interesting applications of the material. When New Zealand was discovered, the natives were found using implements industriously worked in a dark-green stone which they called in the Maori language *punamu*, signifying "green-stone." The most valuable of their "green-stones" was a true nephrite of rich green color, which was obtained along the western coast of the Middle Island, and the natives consequently gave to this district the name of *Te Wahi Punamu*, or "Place of the Green-stone." It is found there *in situ*, and it also occurs as pebbles strewn partly in the beds of rivers and partly

along the sea-shore. It was fashioned with great labor by the primitive natives into axes, adzes, and other implements, and into amulets of varied form. Their most characteristic weapon was the *meré*, or *patu-patu*, a short, flat, leaf-shaped hand-club, which was held by a thong passing through a hole in the handle and securely bound round the wrist. It was only the great Maori chieftains who possessed jade *merés*, which were handed down from generation to generation as precious heirlooms; the ordinary native New Zealander made his *meré* of some other hard stone like serpentine, of heavy wood, or of the blade-bone of a whale. These jade *merés* are described by some observers as tokens of tribal authority or rank.

Precisely similar weapons of jade, by the way, have recently been found in different parts of North America. Doubts were expressed as to the authenticity of the first Indian *patu-patu*, which was reported to have been unearthed from a mound situated south of the Arkansas River, in Bent County, southeast Colorado; but further examination, according to Dr. Thomas Wilson, puts a different phase upon the affair. Mr. J. Wickenham, in a paper entitled "An Aboriginal War-Club,"[1] reports the discovery of a number of these implements in various parts of the American continent. Dr. Wilson figures two "Patu-patu from the United States, similar to those from New Zealand,"[2] one of which was found by a hunter in California tied by a cord to the wrist of a dead Ute Indian; the other in the State of Washington, three miles east of Olympia, while clearing the ground of stumps. Dr. Wilson concludes his interesting *résumé* of the subject by remarking that "it has to be admitted that this is an implement of the North American savage: whether historic or prehistoric may be left undecided."

To return to New Zealand. The curious ornament or amulet known as *tiki*, or *hei-tiki*, which was worn over the heart by Maori chieftains, is well known. It presents the form of a grotesque human figure, generally having its huge eyes inlaid with the iridescent shell of *haliotis*, and sometimes of late years with sealing-wax, the red wax contrasting strongly with the green nephrite. From the fact that the lower edge of the *tiki* is always sharp, it has been inferred that it may have been derived from the type of the celt: perhaps even carved from an actual celt, like the amulets of many other primitive peoples. In New Zealand these *tikis* seem to have had some connection with ancestor worship and mythology, and they were sometimes regarded as symbols of right to hereditary lands.

There is a fine *hei-tiki* in the Collection, No. 315. New Zealand is also represented by a large war-club or *meré*, No. 296, and by a series of fine aboriginal axes and hatchets, besides nine mineralogical specimens.

Nephrite also occurs in New Caledonia, where the natives fashion it into axe-heads, often of large size, like the aboriginal battle-axe in the Collection, No. 297. It is found besides in New Guinea, which is represented in the Collection by Cast R, taken from an aboriginal hatchet in the Dresden Museum, and in several of the smaller Pacific islands. It was in consequence of its frequent use by the South Sea islanders as a material for making axe-heads that nephrite became known to German mineralogists as *Beilstein*, or "axe-stone." Damour described, under the name of "oceanic jade," a fibrous variety found in New Caledonia and in the Marquesas Islands, having a specific gravity of 3.18, and differing from ordinary nephrite in the proportion of lime and magnesia which it contains, but this is not generally recognized as a distinct species. The jade of the Pacific islands is, in fact, generally nephrite, but jadeite is reported to be found in New Guinea. Oceanic jades can hardly have found their way to Europe or to America in prehistoric times, although Fischer went so far as to argue in favor of such a view.

Recent discoveries have shown, by cumulative evidence, that nephrite and jadeite are not so limited geographically as was formerly supposed. M. Alibert has enriched the museums of the world with blocks of lustrous dark-green nephrite boulders found in the vicinity of his graphite-mines at Batougol in Siberia; and many other localities have since been reported in different parts of the country, several of which are represented by specimens in this Collection. It was finally found there *in situ*, in 1897, by Professor L. von Jaczewski, who had been sent to search for a monolith for the tomb of Alexander III. He found large beds of olive-green nephrite on the northern slopes of the Kitoi Mountains, with immense boulders lying beneath, measuring four by three metres, and generously presented several pieces to the Collection, Nos. 101, 107, 108, 109, 111, 115, and 132.

Professor Jaczewski, in his vivid account of his explorations in Siberia in Part III, describes the occur-

[1] American Antiquarian, 1895, Vol. XVII, p. 72.
[2] Report of the United States National Museum, 1896, p. 42.

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No. 297

BATTLE-AXE

Nephrite

New Caledonia

No. 315

NECK-ORNAMENT

(*Hei-tiki*)

Nephrite

New Zealand

rence there of the nephrite mineral, which, he says, fully deserves the name of "rock," in such vast quantities and masses, "that not only sarcophagi, large vases, and similar objects can be cut from it, but also whole columns and monuments." There is one piece in the Collection, No. 134, from Europe, approaching these large dimensions, the block of nephrite extracted from a quarry at Jordansmühl in 1899 by Mr. Kunz, which weighs 2140 kilos. Pale-green nephrite occurs in huge masses, according to Chinese accounts, in the "Jade Mountains" to the southwest of Yárkand in Chinese Turkistan. In Alaska there is also a "Jade Mountain" possessing large seams from which enormous pieces could be taken by modern mining methods. Mining in China has been generally confined to firing and then chilling the rock by water, thus breaking it into small pieces, and I believe that part of the cause of not cutting large pieces of jade during ancient times was on account of the blocks being broken up by this method of mining. That may be a reason in part, but only in part, as, for example, the Jordansmühl piece is mentioned to be so full of seams that it would be impossible to find a perfect piece large enough to make a large vase or any such object. It is reported that in most of the quarries that are being mined in China the same trouble is encountered from the multiplicity of seams and flaws.

In Siberia some of the large pieces found on the river-beds as huge boulders do not seem to have so many seams and flaws, and therefore it is expected that in the future some very large decorative pieces of jade will be fabricated. But the question of transportation is a serious one, and until railroad tracks are laid down such pieces will not be moved to places where lapidaries could, by modern methods, reduce them.

In Chinese Turkistan the oasis of Manas has been identified as a source of the Chinese spinach-green nephrite, as evidenced by the boulder fragment, No. 76, the large water-worn block, No. 78, and some smaller pieces in the Collection.

Africa, so far, has yielded little or no jade, although Fischer records one ancient Egyptian scarabæus carved in jadeite. Feldspar is the usual material used by Babylonian and Assyrian engravers for their cylindrical seals, but there is at least one Assyrian seal in the British Museum carved in jade.

Jadeite implements are included in the interesting discoveries made in Crete a short time ago by Mr. A. J. Evans. These discoveries promise to throw a new light on the beginning of Greek civilization, and are described in his article on "The Neolithic Settlement at Knossos and its Place in the History of Early Ægean Culture."[1] In the neolithic stratum of Knossos, which contains the remains of the first settlement of that period yet explored in the Greek world, supposed to date from before 3000 B.C., an abundance of primitive dark, hand-made pottery, often punctuated and incised, and with inlaid decoration of textile derivation, was found. Mixed with this were over three hundred axes, besides chisels, adzes, hammers, and other stone implements, made of greenstone, serpentine, diorite, hematite, and other materials, in addition to jadeite. The relics exhibit curious Anatolian analogies, and, as Mr. Evans observes, "the continued exploration of the Neolithic remains of Knossos is necessary for the full elucidation of many of the problems suggested by these discoveries." The most interesting problem, from our point of view, is the source and associations of these jadeite implements, and it is to be hoped that more will be discovered in the immediate future.

The present Collection affords no small contribution toward the solution of the interesting questions which have been briefly touched upon in this introduction, as a glance at the Catalogue will show. The list of mineralogical specimens includes many localities in Asia, Europe, North America, and New Zealand. About three fourths of the number come from Asia,—Burma, Tibet, Chinese Turkistan, and Siberia being the countries represented. Of the remaining fourth, one half is attributed to Europe, the localities being Jordansmühl and Reichenstein, Schwemsal in Saxony, Tolna in Hungary, and Neuchâtel in Switzerland; the other half is divided between Alaska, British Columbia, and New Zealand.

With regard to the question as to the existence of jade *in situ* in different parts of the world, I am quite satisfied that if any person should carefully study the specimens of this Collection, arranged as to their locality, he would soon be as satisfied as I am that the specimens found in Mexico originated in that locality; again, those of the Pacific Coast from the north of Mexico to Alaska have their own distinct appearance. Those of Alaska are different from those south of that locality, and they also differ from those of Siberia. They are indigenous to their own localities. The majority of the relics derived from the lake-dwellings of Switzerland

[1] Published in Man, No. 146, 1901.

are of quite a distinct class from those found in any other locality. The same can be said regarding the aboriginal jades of New Zealand and New Caledonia; none exist in any part of the world of the same character and appearance as these last. You will find a great similarity of color and appearance in the implements from France; they are unlike the prehistoric implements of any other locality. Thus far the specimens in the Collection from Siberia are, as a whole, of a different appearance from those of other localities. All the jadeites of Burma seem to be of a distinctive class, and I know of no specimens from any other part of the world similar to them, unless it may be possibly that part of Tibet bordering on Burma. The nearest that approach them are some of the specimens from Mexico, yet any one at all familiar with both will at once see that they vary considerably and would not be recognized as of the same locality.

I am sure that were the labels to be removed from these widely separated groups I could easily distinguish them apart and readily assign them to their proper localities, and that any mineralogist or archæologist would have no difficulty in doing the same.

This, to my mind, settles the question as to the locality of jade *in situ*. I believe that it exists *in situ* and in boulders in all the localities I have mentioned, and that it will be found in many others when sufficient interest develops to seek it.

As to the material, it will surprise most people when it is stated that although jade is such a distinct mineral, yet there are in the whole Collection but few pieces that are perfect as nephrite, chloromelanite, or jadeite. Almost all contain in addition some foreign substance in smaller or greater proportions. You will find a piece that is classified as jadeite because the greater part of it is of that material; the other part may be nephrite. The same may be said of nephrite in which is found some remaining portion that is jadeite. Chloromelanite, which is of the same class as jadeite, may also possess an excess of iron, or possibly may have some nephrite or other foreign substance in smaller quantities. Some pieces have been ruled out of the Collection because the nephrite existed in a smaller quantity than the other mineral constituents of the stone. Yet the experienced collector will rarely make a mistake in selecting correctly a piece of jade. His judgment for a correct selection by touch, temperature, weight, and sight may be relied upon without fear.

The list of archæological specimens, nearly two hundred in number, comprises implements, weapons, and partially worked pieces from all the continents of the world except Africa; a representative series of casts from European museums; a number of ornamental and ceremonial objects of jadeite from Central America, Mexico, and New Zealand; and a selection of old Chinese carved objects which show signs of having been buried in the ground, and are, for this reason, separately classified under the heading of "tomb jades." These include examples of ancient tokens and batons of rank, sacrificial tablets and libation vessels, inscribed celts, amulets, and signets, archers' thumb-rings, armlets, and girdle pendants, wine-ewers and -cups, with other relics of Chinese antiquity. The preceding section throws some light on pre-Columbian Mexican ethnology, exhibiting pendants and beads, miniature masks, carved amulets and other ornaments, labrets or ear-tubes pierced for the insertion of feathers, teeth inlaid with pea-green jadeite, besides two pieces inscribed with hieroglyphs in the ancient Mayan script of great rarity and value. The cast (S) of a pre-Columbian figure of a man with artificially deformed head, wrought in bluish-green jadeite, now in the Imperial Museum at Vienna, and which is probably of Mexican origin, may also be alluded to in this connection. But these things are all fully described in the Catalogue and need simply to be referred to here.

Next we come to the art objects of jade, in which the material has been in turn shaped by the saw, carved in relief by the lapidary's wheel, pierced with open-work designs by the diamond drill, and ground and polished in various ways to prepare the object for artistic decoration, for personal ornament, or for any of the other uses to which jade is adapted. China is the chief country of the craft, and the bulk of every collection of jade is always Chinese. For this reason Part II is devoted to "Jade in China." It consists mainly of a learned essay written expressly for these pages by T'ang Jung-tso, a Chinese scholar, a native of Peking. This is printed in the original Chinese, with an English translation, and an introduction referring to old Chinese literature on the subject. The essay is followed by a series of water-color illustrations, painted on the spot by Li Shih-ch'üan, the Chinese artist who has since so well illustrated the magnificent "Description of Peking" written by Monseigneur Favier, the celebrated bishop of the Lazarist Mission there. These illustra-

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No. 516

ARTIST'S BRUSH-HOLDER

(*Pi T'ung*)

Ch'ien-lung (1736–95)

Jadeite

tions give realistic and authentic pictures of the various processes of work followed by the Chinese craftsman, which, it is hoped, will be appreciated as both interesting and novel as well as quaint.

Part III, entitled "Jade as a Mineral," is the most important and valuable part of the volume, jade being treated as a mineral in its widest sense with a completeness and scientific accuracy never previously attempted. The services of the distinguished scientists whose careful work is enshrined here have been gratefully acknowledged in the Preface. Among the questions of more general interest which are treated in detail are the following: The colors of jade, whether natural or the result of weathering or staining; the translucency, lustre, opalescence, sheen, and other qualities which ennoble it as a material for artistic work. The great tenacity of jade, a characteristic property, proved by a series of tests showing its resistance to impact, compression, and tension. Its special sonorousness, or resonant quality, which makes it valued by the Chinese as a material for musical instruments. The relative hardness and specific gravity of jadeite and nephrite, their different chemical constitution, and the localities of their geological occurrence are fully discussed. The relations of jadeite and nephrite and the other studies of microscopical petrography which throw some light on the origin of jadeite are novel and most suggestive. The collector and connoisseur of art will find the description of the many minerals sometimes mistaken for jade, and the means of detecting them, which concludes the series, of no small interest and value.

Part IV is devoted to a sketch of the methods of working jade at different times and in different countries. It begins with an account of the work as it is carried on to-day by the Chinese lapidary at Peking, based upon the naturalistic water-color illustrations in Part II, which were painted on the spot by the Chinese artist. We are indebted to his labors for an exact knowledge of every step of the Chinese jade-carver as he elaborates, from start to finish, one of the artistic triumphs for which the Collection is remarkable. From China we pass to India and its jewelled jades, glance at Persia with its sword-hilts and amulets of jade, and compare the methods of work followed in these countries now with those of classical times, and with the processes adopted by the skilled European lapidaries of modern days, who continue to use the same old tools, only with their power increased by being whirled more rapidly by steam and electricity. But such perfect instruments must have been very gradually evolved from small beginnings, starting from the primitive methods by which prehistoric peoples fashioned their jade tools and weapons. The connection is worked out by a study of the prehistoric objects in the Collection and by a comparison of the methods revealed by their study with those followed in recent times by certain uncivilized races, such as the Maoris of New Zealand and the Alaskans of North America, in the manufacture of their aboriginal implements of jade.

Part V is entitled "Worked Jade" and is intended to give a general summary of the subject under the two headings of Prehistoric and Historic. The usual meaning of the word "prehistoric" is somewhat widened so as to include in the first class the relics of savages who lived prior to the beginning of history in their several localities. The second class includes all the artistic specimens of the lapidary's art, the product of more civilized peoples in historic times, which make up the bulk of the Collection. They are fully described in the Catalogue which forms the second volume, and have been referred to here only to give a general view of the various uses and purposes for which jade has been worked and some of the points which contribute to its artistic value.

A short bibliography of some of the older authors on jade consulted for this Historical Introduction is appended. One or two other references will be found in the notes to subsequent parts of the volume.

Forbes, Boston.

No. 325

SACRIFICIAL TABLET

(*Kuei Pi*)

Previous to Han Dynasty

No. 330

ARCHER'S THUMB-RING

(*Pan Chih*)

Han Dynasty (B. C. 206–A. D. 220)

Nephrite

No. 324

SMALL CELT

(*Hsiao Chan*)

Previous to Han Dynasty

Nephrite

No. 317

TABLET OF RANK

(*Kuei*)

Previous to Han Dynasty

Nephrite

No. 331

ANCIENT SIGNET

(*Kang Mao*)

Han Dynasty (B. C. 206–A. D. 220)

Nephrite

"TOMB JADES" OF CHINA

17

PART II

JADE IN CHINA

INTRODUCTION

BY STEPHEN W. BUSHELL

YÜ SHUO

A DISCOURSE ON JADE

(CHINESE TEXT)

BY T'ANG JUNG-TSO

WITH TRANSLATION BY S. W. BUSHELL

YÜ TSO T'OU

ILLUSTRATIONS OF THE MANUFACTURE OF JADE

BY LI SHIH-CH'ÜAN

WITH CHINESE MANUSCRIPT NOTES

TRANSLATED BY S. W. BUSHELL

JADE IN CHINA

ITS PLACES OF PRODUCTION, VARIETIES, LITERATURE, AND MANUFACTURE

BY STEPHEN W. BUSHELL, C.M.G., M.D.

PHYSICIAN TO H. B. M. LEGATION, PEKING, CHINA

AN INTRODUCTION TO *YÜ SHUO* BY T'ANG JUNG-TSO

AND *YÜ TSO T'OU* BY LI SHIH-CH'ÜAN

CONTENTS

Reverence of the Chinese for Jade

The Character *Yü.* Jade Rivers

Mountains, Towns, and Quarries of Khotan

Jade of Chinese Turkistan according to Ying Ho

Jade of the Mirtái Mountains and from Yúrúngkásh River

Present Supply to Peking

Ch'ien-lung Jade

Burmese

Ancient and Prehistoric

Insignia of Rank

Symbols in Worship

Talismans and Amulets

Detailed Reference to
Po ku t'ou (Illustrations of Ancient Bronze, thirty books);
K'ao ku t'ou (Illustrated Researches of Antiquities, ten books); and
Ku yü t'ou (Illustrations of Ancient Jade, two books),
as one work edited by Huang Shêng in 1753 A. D.; and to
Ku yü to'u pu (Illustrated Description of Ancient Jade, one hundred books),
edition of 1779 A. D.

With Chinese and English Versions of a Map of the Jade-producing
District of Chinese Turkistan

No. 654

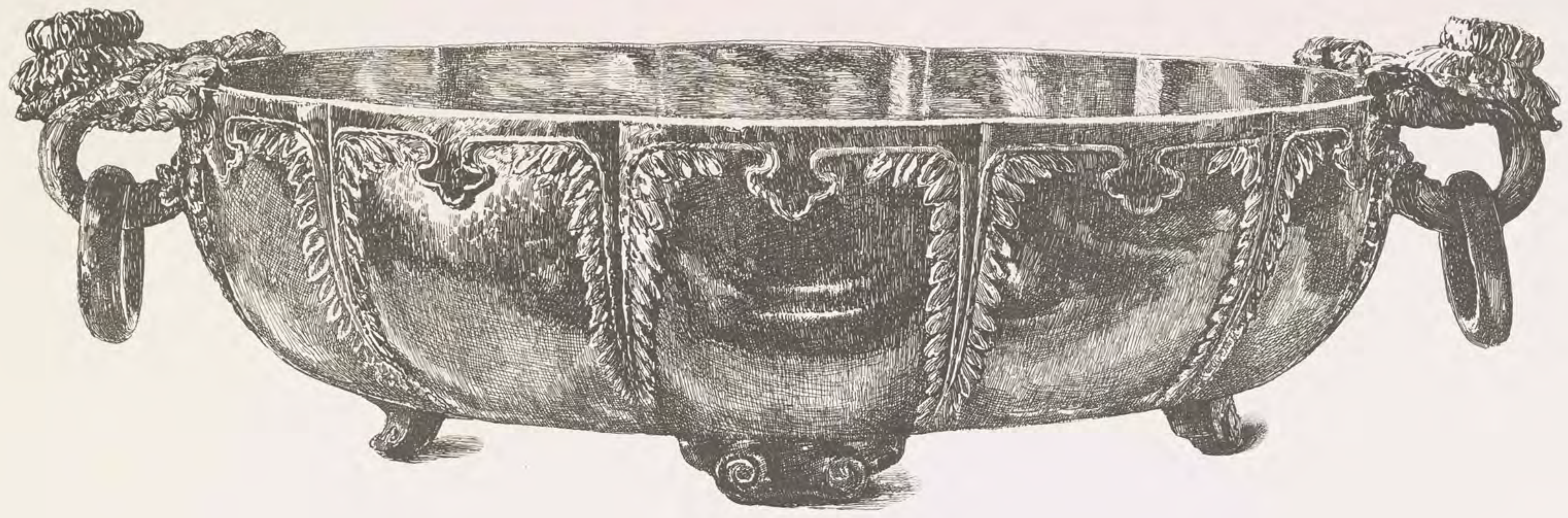
BUDDHIST COLUMN

(*Fo T'ung*)

Ch'ien-lung (1736–95)

Nephrite

21



JADE IN CHINA

INTRODUCTION

I HAVE been asked to write a few words on Chinese Jade, by way of introduction to the learned "Discourse on Jade," by my friend T'ang Jung-tso,[1] which is remarkable not only for its research into the vast store of native literature, but also for the knowledge it shows of ancient and modern work in Jade. It has been written to illustrate the remarkable collection of Mr. Heber R. Bishop, who requested "a condensed article on jade by a native Chinese scholar, treating upon its uses in China from the earliest period down to the present day; stating what appreciation it obtained when first brought into use, and for what purposes it was used; a general statement of the estimation in which it was held, and of the general sentiment associated with it on the part of the Chinese, especially regarding it in its crude condition, as well as when worked into forms for implements or artistic purposes. If they have any particular religious associations with it, that should also be stated; and then also to what extent it was used and appreciated by the Imperial Government; and to what extent it is now mined, and for what purposes."

[1] In Chinese names the surname comes first, the next two syllables connected by a hyphen being the personal name. Chinese is a strictly monosyllabic language, and in the transcription of foreign names, in the same way as in that of the native Manchu, each syllable must be rendered by one or more Chinese characters, e. g., *Bi-sho-po* for Bishop. I have followed Sir Thomas Wade's system of orthography, which is now so generally adopted, as by my friend Mr. Hippisley, in the Catalogue of his Collection of Chinese Porcelain published by the Smithsonian Institution, Washington, 1890. Professor Giles, in his large Chinese dictionary, uses the same system of transliteration.

With regard to pronunciation, the consonants are generally pronounced as in English, with the exception of *j*, which is nearly the French *j* in *jaune*, the English *s* in *fusion* or *z* in *brazier*. The initials *ch*, *k*, *p*, *t*, *ts*, *tz*, occur also aspirated, and the aspirate which intervenes between them and the vowel following is indicated by an apostrophe in preference to an *h*, lest the English reader should pronounce *ph* as in *triumph*, *th* as in *month*, and so on. To pronounce *ch'a*, drop the italicized letters in *mu*ch-har*m*, for *t'a* drop the italics in *hi*t-har*d*. The initial *hs*, with a slight aspirate preceding and modifying the sibilant, is a peculiar sound which can be acquired only by practice.

The vowels and diphthongal sounds are pronounced as in Italian, in accordance with the following table:

Vowel Symbols	Webster's System	English Value
a	ä	a as in *father*
e	ĕ	e as in *yet*
ê	ẽ	e as in *fern*
i	ī = ē	i as in *marine*
ih	ĭ	i as in *pin*
o	ô	o as in *lord*
u	ṳ	u as in *prune*
ü		ü as in German *München*
ŭ	ĭ or ŭ	between *i* in *bit* and *u* in *shut*

For the last vowel sound, *ŭ*, which is found only with the initials *ss*, *tz*, *tz'*, we have no equivalent in English. In the diphthongal sounds each of the vowels is separately pronounced in the Italian fashion; thus, *ai*, nearly our *aye*, is better represented by the Italian *ai* in *hái*, *amái*; *ia*, by the Italian *ia* in *piazza*; *ie* is pronounced as in the Italian *siesta*, *niente*, etc. Each Chinese monosyllable has its own special tone or musical intonation, but for this the inquirer must be referred to special works on the subject.

The Chinese author has, in accordance with these instructions, which were communicated to him by me, divided his article into nine sections, entitled:

I Sources of Jade
II Crude Jade
III Value of Jade
IV Objects made of Jade
V Jade used by the Son of Heaven
VI Jade used by the State
VII Colors of Jade
VIII Ancient Jade
IX Fei-ts'ui

It concludes with an Appendix, containing the titles of seventy-one books quoted in the article, which range through at least three thousand years, and belong to every class of literature, from the official annals to the relations of Taoist legend. I have given the names of most of the writers of these books, and their approximate dates. The "Discourse" itself I have translated as literally as possible, so as to try to convey the spirit of the original. There is hardly space for comment or for minute criticism of details, even were it advisable.

The Chinese seem to have had the highest appreciation of jade from prehistoric times, before the migration of the black-haired race to China, and while they were still, perhaps, residents of Central Asia, the native country of the best jade. This is shown by the frequent reference to it in the classical books and in the early annals. Jade is often, for example, referred to in the "Shu Ching," which is a collection of early contemporary documents arranged as we now have them by Confucius, who lived B.C. 551–479, under the Chou dynasty.

The Chou was the third of the three ancient dynasties with which authentic Chinese history begins, after a prolonged fabulous and legendary period ending with the reigns of Yao and Shun, which head the first chapters of the "Shu Ching," the classical Book of Annals. The successor of the emperor Shun, Yü the Great, was the founder of the Hsia dynasty, under which the rule was handed down in hereditary succession till his house was overthrown by T'ang the Successful, the founder of the Second dynasty, the Shang or Yin. The reigning Manchu dynasty is the twenty-fifth in the line according to the following table:

ABSTRACT OF THE CHINESE DYNASTIES

Dynasty	Remarks	Began	Duration Years
1 Hsia	17 sovereigns	B.C. 2205	439
2 Shang	28 sovereigns. The 16th, P'an Kêng, changed the dynastic title to Yin, B.C. 1401	1766	644
3 Chou	34 sovereigns. The 13th, P'ing Wang, moved the capital to Lo, B.C. 770, founding the Eastern Chou. Confucius flourished B.C. 551–479	1122	867
4 Ch'in	Founded by Ch'in Shih-huang, builder of the Great Wall, whose son reigned only 3 years	255	49
5 Han	Styled Western Han from the site of its capital at Ch'angan, now Hsi-an-fu. 14 emperors	206	231
6 Later Han	Also styled Eastern Han from its capital at Lo-yang, in the province of Honan. 12 emperors	A.D. 25	196
7 Minor Han	2 emperors. Divided the empire with the Wei and Wu Epoch of Three Kingdoms. San Kuo	221	44
8 Chin	4 emperors	265	52
9 Eastern Chin	11 emperors. The founder, Yuan Ti, removed the capital to Chien-K'ang, now Nanking	317	103
10 Sung	8 emperors } Epoch of Division between North and South, Nan Pei Ch'ao, the Tartar dynasties of Wei (386–549), Ch'i (550–577), and Chou (557–581) ruling the North.	420	59
11 Ch'i	5 emperors	479	23
12 Liang	4 emperors	502	55
13 Ch'ên	5 emperors	557	32

ABSTRACT OF THE CHINESE DYNASTIES (*Continued*)

Dynasty	Remarks	Began	Duration Years
14 Sui	3 emperors	589	29
15 T'ang	20 emperors	618	289
16 Posterior Liang	2 emperors — Epoch of the Five Dynasties—Wu Tai—during which 13 rulers reigned only 53 years.	907	16
17 Posterior T'ang	4 emperors	923	13
18 Posterior Chin	2 emperors	936	11
19 Posterior Han	2 emperors	947	4
20 Posterior Chou	3 emperors	951	9
21 Sung	9 emperors	960	167
22 Southern Sung	9 emperors. Shared the empire with the Chin Tartars (1115–1234)	1127	153
23 Yuan	9 emperors. Founded by Kublai Khan, grandson of Genghis Khan	1280	88
24 Ming	17 emperors	1368	276
25 Ch'ing	The present Manchu Tartar line, of which the 9th emperor, Kuang Hsü, is now reigning	1644	

THE MING DYNASTY

Dynastic Title, or *Miao Hao*	Title of Reign, or *Nien Hao*	Year of Accession	Dynastic Title, or *Miao Hao*	Title of Reign, or *Nien Hao*	Year of Accession
T'ai Tsu	Hung Wu	1368	Hsiao Tsung	Hung Chih	1488
Hui Ti	Chien Wên	1399	Wu Tsung	Chêng Tê	1506
Ch'êng Tsu	Yung Lo	1403	Shih Tsung	Chia Ching	1522
Jên Tsung	Hung Hsi	1425	Mu Tsung	Lung Ch'ing	1567
Hsüan Tsung	Hsüan Tê	1426	Shên Tsung	Wan Li	1573
Ying Tsung	Chêng T'ung	1436	Kuang Tsung	T'ai Ch'ang	1620
Tai Tsung Ching Ti	Ching T'ai	1450	Hsi Tsung	T'ien Ch'i	1621
Ying Tsung (restored)	T'ien Shun	1457	Chuang Lieh Ti	Ch'ung Chên	1628
Hsien Tung	Ch'êng Hua	1465			

THE REIGNING (CH'ING) DYNASTY

Dynastic Title, or *Miao Hao*	Title of Reign, or *Nien Hao*	Year of Accession	Dynastic Title, or *Miao Hao*	Title of Reign, or *Nien Hao*	Year of Accession
Shih Tsu Chang Huang Ti	Shun Chih	1644	Hsüan Tsung Ch'êng Huang Ti	Tao Kuang	1821
Shêng Tsu Jên Huang Ti	K'ang Hsi	1662	Wên Tsung Hsien Huang Ti	Hsien Fêng	1851
Shih Tsung Hsien Huang Ti	Yung Chêng	1723	Mu Tsung Yi Huang Ti	T'ung Chih	1862
Kao Tsung Shun Huang Ti	Ch'ien Lung	1736	(The Reigning Sovereign)	Kuang Hsü	1875
Jên Tsung Jui Huang Ti	Chia Ch'ing	1796			

Kuan Tzŭ, the famous Minister of Duke Huan[1] of Ch'i, who lived in the seventh century B.C., writes in his book on political economy: "Jade comes from Ou-ti, gold comes from Ju Han, pearls are produced in Ch'ê-yeh. The former kings, because these things came from afar, and were obtained with difficulty, made use of them according to the respective value of each, pearls and jade being estimated highest, gold placed in the middle class, copper knives and spade-shaped coins belonging to the lowest class."

The character *yü*, meaning jade, is a very ancient one. It consisted originally of three horizontal lines, connected by a vertical line, representing three stones strung together, the dot on the right being a modern

[1] Duke Huan (B. C. 693–642) was the fifteenth hereditary prince of Ch'i, a state situated in the north of what is now the province of Shantung, a fief bestowed by Wu Wang, the founder of the Chou dynasty, upon Shang-fu, one of his chief advisers both in peace and in war. For thirty-nine years Duke Huan was the acknowledged head of the confederacy of states which ruled the internal affairs of China under the nominal sovereignty of the house of Chou, owing his success in great measure to the advice and statesmanship of his famous counsellor, Kuan Chung, who died in B. C. 645, and who is enrolled in the list of sages under the title Kuan Tzŭ, and is the author of the philosophical book on government and legislation which bears his name. The feudal princes at this period were ranked as *kung*, *hou*, *po*, *tzŭ*, and *nan*, fairly rendered duke, marquis, earl, viscount, and baron. These hereditary titles are still used in China, although the feudal system, as in Europe, is long extinct.

addition, to distinguish it from the similar character, *wang*, king. Two characters, placed side by side, and read *chüeh*, meant two pieces, and the character *chü*, the original form of which was *yü*, jade, three times repeated, signified, specially, ten pieces of jade.[1]

Marco Polo was the first European to visit the district of Khotan, celebrated for its jade. He passed through it on his way to China, in the thirteenth century, and refers to the quantities of jade, which he calls jasper, and chalcedony found in the rivers of the country.[2] A more detailed account of the "fishing" for jade is found in the diary of Chang Kuang-yi, an envoy from the Emperor of China to Khotan in the tenth century, as described by our author. He alludes to three rivers, called White Jade River, Green Jade River, and Black Jade River, from the different colors of the pebbles of jade found in their beds. An Arab historian of Timur[3] (Tamarlane) tells of the two rivers of Khotan, whose stones are of jasper (*yeshm*), called Orangkásh and Karakásh, signifying in the Eastern Turki tongue White jade and Black jade, and adds that these two rivers have their source in the mountain of Kárangotág. These names may all be found in modern Chinese maps of Eastern Turkistan, and they are placed at about the same distances from Khotan as by Chang Kuang-yi over nine centuries ago. The walled city of Karakásh, 70 li[4] northwest of Khotan, and the village of Yúrúngkásh, 10 li east of Khotan, both take their names from the rivers on which they stand. Johnson, describing his visit to Khotan in 1865, talks of jade as "obtained from the Kárangoták Mountains at a height of 8735 feet."

These mountains are really part of the great K'un Lun Range, and the same as the K'un Mountains referred to in the Itinerary of Chang Kuang-yi as the source of the Jade Rivers. This range, which starts in the east from the borders of China Proper, on the south of the lake Kokonor, forms the boundary line between Chinese Turkistan and Tibet. I have compiled the accompanying maps of the jade-producing districts of Chinese Turkistan, from Chinese sources, to illustrate this paper. They are based upon the maps produced after the surveys made by British and Russian officers, which were published at Dehra Doon, at the Office of the Great Trigonometrical Survey of India in 1875, compared with more recent maps published in the Journals and Proceedings of the Royal Geographical Society of London, to illustrate the journeys of Lieutenant Younghusband and other travellers. The K'un Lun Range may be seen traversing the map from southeast to northwest, it being known by various names in different parts of its course. The part to the south of Khotan is called Nan Shan, or Southern Mountains, which is continuous on the west with the Margulugh Mountains, and these pass into the Mirtái Mountains, which last extend northward as far as the town of Khusharáb (meaning "Twin Peak Stream"), where the Yárkand or Zarafshán ("Gold-scattering") River emerges through a precipitous defile. These Mirtái Mountains are described in the paper of T'ang Jung-tso as situated 230 li southwest of the town of Yárkand, under the name of Mirtái Tapan, Tapan standing here for Dabán, which in Manchu signifies "mountains." They are usually called in older Chinese books the Bilor Mountains, and it is by this name, or the Turki form, Belurtág, that they are generally described in European works. It seems likely that this name of Mirtái, also written Milotai, is merely a corruption, or rather a dialectal variation, of Bilotág, the final syllable being softened and the *b* replaced by *m*. This latter change is a common one in the dialect of the Kirghis mountaineers, who always, for example, pronounce Táshbalik ("Stone-town"), Táshmalik. These Mirtái Mountains, which are described as covered with perpetual snow, extend nearly ten miles from base to summit, and are composed of three series of strata, of which the middle series contains the jade, the lowest and highest being formed of common rock. They are called Yü Shan, or "Jade Mountains," in modern Chinese geographical books, just as the Zarafshán, the "Gold-scatterer," is known to the Chinese by the alternative name of Yü Ho, or "Jade River." In ancient times, as shown above, the chief supply of jade was obtained from places within the boundaries of the district of Khotan; in modern times the largest quantity comes from Yárkand. All the principal mountain quarries and jade-producing rivers are comprised within these two provinces.

There are many Chinese books on Turkistan (Hsi Yü). Among the most important are the voluminous geographical description, with maps, entitled "Hsi yü t'ou chih," published by imperial commission in the

[1] *Yü*, jade, 玉; *wang*, prince, 王; *chüeh*, 玨; *chü*, 區.

[2] The Book of Ser Marco Polo, newly translated and edited with notes by Colonel Henry Yule, C. B., R. E. In two volumes, London, 1871. A second edition, revised, with new matter and more illustrations, was published in 1875. Both editions are now out of print and scarce.

[3] Histoire de Timur, traduit par Petis de la Croix, Tome III, p. 219.

[4] A li may be roughly estimated at one third of an English mile.

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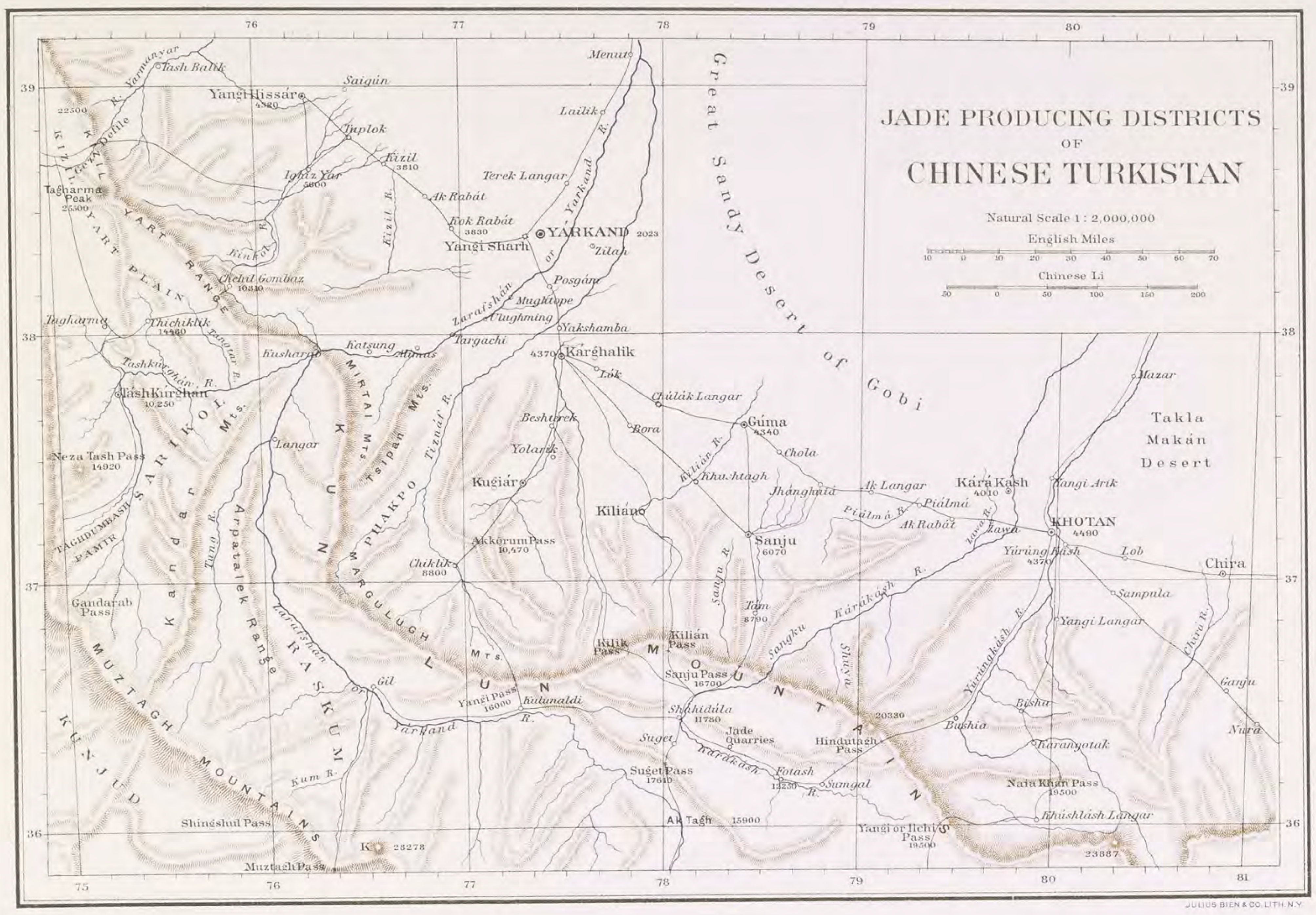
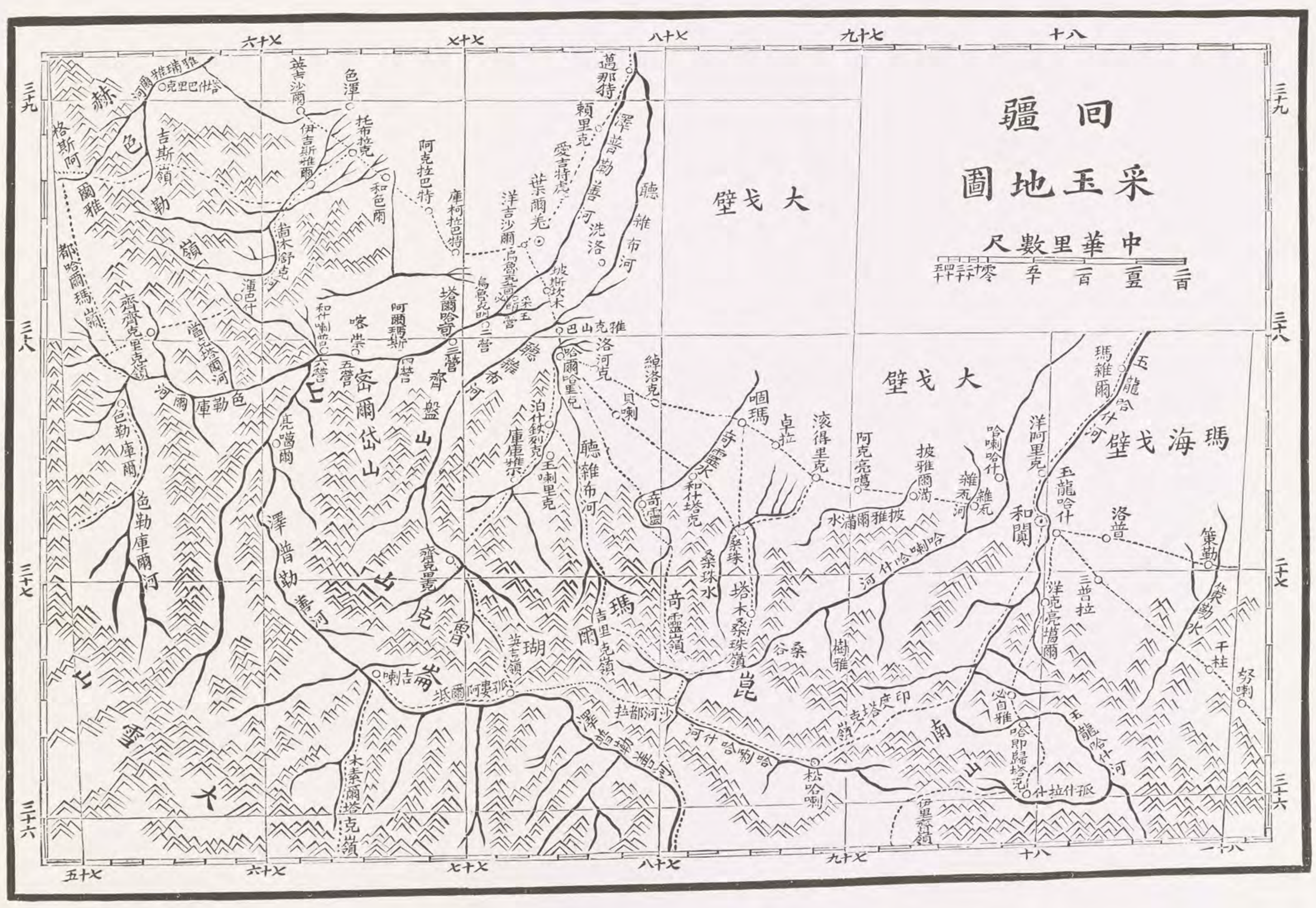
JADE-PRODUCING DISTRICTS
OF CHINESE TURKISTAN


JADE PRODUCING DISTRICTS
OF
CHINESE TURKISTAN
Natural Scale 1 : 2,000,000
English Miles
Chinese Li
Great Sandy Desert of Gobi
Takla Makán Desert
YARKAND
Kárghalik
KHOTAN
Chira
Guma
Sanju
Kilian Pass
Sanju Pass
Jade Quarries
Shahidula
Tashkurghan
Muztagh Pass
Karakash
JULIUS BIEN & CO. LITH. N.Y.


回疆采玉地圖
中華里數尺
大戈壁
瑪海戈壁
和闐

reign of the emperor Ch'ien Lung, and the "Hsin chiang chih lüeh," another detailed description of the New Dominion (Hsin Chiang), issued also with the imperial imprimatur in A. D. 1821, the first year of the reign of the emperor Tao Kuang. I have taken the Chinese names of the places principally from these two works, the original Turki names being so variously transliterated in Chinese by different authors.

A fuller account of the jade quarries is to be found in the "Hsi Yü Shui tao chi" ("Description of the Rivers of Chinese Turkistan"), in five books, by Ying-ho, a learned Manchu officer, published in the year 1823. This gives an itinerary from Yárkand to the mines in the Mirtái Mountains, 410 li distant:

From Yárkand to Posgám, south, 70 li
Posgám to Khan Langar, southwest, 50 li
Khan Langar to Yengi Chuang, southwest, 150 li
Yengi Chuang to Tsipan Mountains, southwest, 30 li
Tsipan Mountains to Atzu Khansar, southwest, 50 li
Atzu Khansar to Mirtái Mountains, southwest, 60 li

It also gives, under the description of the Yárkand River, an account of the stations along the course of the river-bed at which the camps are pitched when the Mohammedan natives are levied for the "jade-fishing." This starts from Khusharáb, a town the name of which is derived from words meaning "twin peaks" and "water," where the river emerges from the precipitous K'un Lun Range, some 260 li distant in a southwesterly direction from the chief town of Yárkand. This is the "sixth jade camp," situated on the south bank of the river. Forty li from this is the town of Katsung, the "fifth jade camp"; 60 li further, the town of Alimas, the "fourth jade camp,"—both situated on the north bank. Fifty li in a northeasterly direction from Alimas we come to the village of Targachi, the "third jade camp"; 30 li northeast of this, to Ulughming, the "second jade camp"; and 30 li northeast of this, to Ulughtop, "the first jade camp,"—all these three being pitched upon the south bank of the river. This "first jade camp" is distant 50 li in a southwesterly direction from Yárkand. When the expedition is on foot the camps are pitched for some three days at each of these stations, so that the river-bed may be thoroughly searched, and the men are finally sent out into the mountains at Katsung, to complete the tally of the quantity required for the annual imperial tribute. No piece of less weight than two ounces is accepted.

The jade produced here is said to be of the best quality, of brilliant color and strong substance, and to emit the clearest sound when struck with the hammer, vibrating for a long time, till the sound stops abruptly in the way characteristic of jade. In the twenty-ninth year of Ch'ien-lung (1764), as Ying-ho relates, the Governor of Yárkand forwarded to the Emperor thirty-nine large slabs, weighing altogether 3975 catties (the catty being equivalent to $1\frac{1}{3}$ lbs.),[1] to make the peculiar musical stones called *ch'ing*, besides a large supply of smaller slabs; and, the year after, sent a further large quantity for imperial use. The slabs were all quarried in the Mirtái Mountains, and sawn there by natives of Sungaria.

These ch'ing are figured in "Ta Ch'ing hui tien," the Government Statutes of the reigning dynasty, as well as in several foreign books on Chinese music.[2] They are carved in the form of an obtuse-angled carpenter's square with two limbs, the longer one called the "drum"; the shorter, the "limb"; and are perforated near the angle to be suspended by silk cords on the wooden frames, which are elaborately carved in the form of phenixes and hung with silk tassels, the jade stones being decorated in gold with dragons in pursuit of pearls. They are modelled after an ancient design figured by Biot,[3] the different parts having a definite

[1]

24 chu, or pearls,	make 1 liang, or tael,	= $1\frac{1}{3}$ oz. avoirdupois	
16 liang	make 1 chin, or catty,	= $1\frac{1}{3}$ lbs.	"
100 chin	make 1 tan, or picul,	= $133\frac{1}{3}$ lbs.	"

The ordinary measures of length are:

10 fên, or lines,	make 1 ts'un, or inch		
10 ts'un	make 1 ch'ih, or foot,	= 12.1 inches,	English
5 ch'ih	make 1 pu, or pace,	= 5.064 feet,	"
2 pu	make 1 chang	= 10.128 "	"
180 chang	make 1 li	= 1895. "	"
200 li	make 1 tu, or degree		

This was the table used by the missionaries in their survey of the Chinese empire in the year 1700, based upon the ch'ih used by K'ang-hsi in the palace, and Regis informs us that Parennin found the degree to contain 200 li, each measuring 180 chang of 10 ch'ih.

Afterward the present rate of 250 li to a degree was adopted in order to make it one tenth of a French league and one twenty-fifth of a degree, and this last scale is found on the charts of D'Anville and in most modern Chinese maps. (See The Chinese Commercial Guide, by S. W. Williams, LL.D., Chapter V, Moneys, Weights, etc., in China.)

[2] Chinese Music, by J. A. Van Aalst. Publications of Chinese Imperial Maritime Customs. II. Special Series: No. 6, 1884, pp. 48, 49.

[3] Le Tscheou Li, ou Rites des Tscheou, traduit par E. Biot, 1851, Tome II, p. 531.

numerical proportion, so that if the breadth of the drum is represented as 1, the length of the limb is 2, the length of the drum 3, and the breadth of the limb 1½. These *ch'ing* are used only in imperial ceremonies, and are of two kinds, the *t'ê ch'ing*, or "single musical stones," and the *pien ch'ing*, or "stone chime."

The *t'ê ch'ing* are twelve in number, giving the twelve notes of the Chinese diatonic scale. Each one is hung on a separate wooden frame and struck with a hammer of hard wood. They vary in size and thickness from the largest, which has the drum 2.187 feet long, .729 foot broad, the limb 1.458 long, 1.0925 broad, and is .0729 thick, to the smallest, which has the drum 1.152 feet long, .384 foot broad, the limb .768 long, .576 broad, and is .1296 thick.

The *pien ch'ing*, or "stone chime," comprises sixteen pieces of jade of similar form, all of the same size, but of different thicknesses, and suspended on one wooden frame, in two rows of eight. They have the drum 1.0935 feet long, .3645 foot broad, the limb .729 long, .54675 broad, and range in thickness from .06068 to .1296 of a foot. The thickest gives, of course, the deepest note; and the jade chime includes four lower notes in addition to the ordinary twelve of the diatonic scale. Mr. Van Aalst gives the scale in common musical notation, and adds that the special function of the jade instruments is to give one sound at the end of each word of the air, in order to "receive the sound" and transmit it to the next word. They are exclusively used in court religious ceremonies, but there are other musical stones carved out of jade for private use, like those in the form of a bat, symbol of happiness, and of two fish,[1] symbol of fertility, figured in the same paper. These are called *chi ch'ing*, propitious musical stones, and are often given as presents, like the ju-i jade sceptres.

To return to our Chinese book on Turkistan. It relates, further, that in the forty-ninth year of Ch'ien-lung (1784) an official of the imperial household was despatched to Yárkand with seventy workers in jade, who brought back five hundred large tablets of jade to be engraved with imperial patents of rank, etc., and fifty large square pieces to be carved into state seals, as well as three hundred smaller tablets and thirty small blocks for seals, the total weight of which amounted to four thousand seven hundred and fifty-two catties.

In the fifty-fifth year (1790) of the same reign there was a fire in the palace, in which all the musical instruments were burned; and the Governor of Yárkand had sixty-four large slabs and eight smaller ones, for the manufacture of new *ch'ing*, mined from the Margulugh Mountains,[2] which produce a fine jade of green color, dark and brilliant, marked with blood-red stains. This was brought to the city of Yárkand by the Mohammedan natives of the Yolarik Mountains, distant 270 li southwest of Yárkand, and went therefore under the name of Yolarik jade.

The jade quarries in the Mirtái Mountains had been closed on account of trouble with natives, but in the fourth year of Chia Ch'ing (1800) they were opened again, and there were quarried ten thousand catties of the finest green jade, eight thousand catties of onion-green[3] and white of the second quality, and three thousand catties of white jade in smaller pieces. This immense weight was carted as far east as Karashár, but had to be left there on account of the difficulties of transport. "When I [Ying-ho] had passed the Ushaktal (Dwarf Willow) Military Station, which is 220 li northeast of Karashár, the natives guiding me to the next stage showed the jade to me, lying in a heap on the northeast of the road, half buried under a pile of dust, more than two feet above the level of the ground."

Then follows an account of the more recent regulations for fishing for jade in the bed of the Zarafshán River, and of the six camps on its banks, occupied by the native Mohammedans in the autumn, when five hundred men were levied for the work, each ten under an *onbashi*, to get the yearly quantity of eighteen thousand five hundred catties requisitioned by the Emperor.

In addition to all of this jade levied from the Yárkand country, a supply was also still requisitioned from the district of Khotan, according to a memorial from the governor dated the fourth year of Chia Ch'ing (1800), which stated that jade was obtained from five different places; but added that only that fished from the Yúrúngkásh River was of good quality, and he accordingly proposed that the supply from the Karakásh

[1] *Chi ch'ing yu yü*, "a propitious stone with fish," gives the punning meaning of "good luck and abundance," the second and fourth characters being replaced by others of the same sound.

[2] The Margulugh Mountains, which form part of the great K'un Lun Range, pass into the Mirtái Mountains on the north and are continuous with the Nan Shan, or Southern, Mountains of Khotan towards the southeast. They are almost unexplored and are sparsely peopled by the curious Aryan race of Thakpo, photographed and described by Sir Douglas Forsyth in the Report of his Mission to Yárkand in 1873.

[3] "Onion-green" of the Chinese is our "grass-green." The simile refers to the color of the young sprouts, not to the bulb of the onion.

River, Sangku, Shuya, and the Karango Mountains should be stopped, and that the first river only should be fished for fifteen days during the autumn, to supplement the supply of fine jade from Yárkand, as the largest pieces found there were also fit for the manufacture of the musical stones.

The Karakásh River, the name of which means "black jade," has always been one of the chief sources of the mineral. Sangku is about 300 li southwest of Khotan, situated near the defile through which the Karakásh River pierces the K'un Lun Range; Shuya, also on the northern slope of the range, lies to the east of Sangku, in the valley of a small tributary of the same river; Kárangoták, which signifies in Turki "Dark Mountains," is described as 200 li due south of Khotan, on the northern bank of the Yúrúngkásh River. The natives of Khotan have always fled for refuge to the rugged wooded glades of these hills when attacked by Turk or Tartar nomads from the north, as related by Rémusat.[1]

Afterward the Mohammedan rebellion broke out in Eastern Turkistan and the jade quarries were closed, there being no further demand from China, and no more trade was allowed during the rule of Yakub Beg at Kashgar (1865–77).

It was during this reign that some of the deserted quarries in the upper part of the Karakásh River valley were visited by Dr. Stoliczka, the naturalist attached to Sir Douglas Forsyth's Yárkand embassy, who was there in the year 1873. He writes:

The portion of the Kuenlún Range which extends from Shahidula eastward towards Khotan appears to consist entirely of gneiss, syenitic gneiss, and metamorphic rocks, these being quartzose, micaceous, or hornblendic schists. On the southern declivity of this range, which runs along the right bank of the Karakásh River, are situated the old jade mines, or rather quarries, formerly worked by the Chinese. They are about seven miles distant from the Kirghis encampment, Belakchi, which itself is about twelve miles southeast of Shahidula. I had the pleasure of visiting the mines in company with Dr. Bellew and Captain Biddulph, with a Yárkandee official as our guide.

We found the principal jade locality to be about one and a half miles distant from the river, and at a height of about five hundred feet above the level of the same. Just in this portion of the range a few short spurs abut from the higher hills, all of which are, however, as usually, thickly covered with débris and sand, the result of disintegration of the original rock. The whole has the appearance as if an extensive slip of the mountain-side had occurred.

Viewing the mines from a little distance, the place seemed to resemble a number of pigeon-holes worked in the side of the mountain, except that they were rather irregularly distributed. On closer inspection we saw a number of pits and holes dug out in the slopes, extending over a height of nearly a couple of hundred feet, and over a length of about a quarter of a mile. Each of these excavations had a heap of fragments of rock and jade at its entrance. Most of them are only from ten to twenty feet high and broad, and their depth rarely exceeds twenty or thirty feet; only a few show some approach to low galleries of moderate length, and one or two are said to have a length of eighty or a hundred feet. Looking on this mining operation as a whole, it is, no doubt, a very inferior piece of the miner's skill; nor could the workmen have been provided with any superior instruments. I estimated the number of holes at about a hundred and twenty, but several had been opened only experimentally, an operation which had often to be resorted to on account of the superficial sand concealing the underlying rock.

The rock of which the low spurs at the base of the range are composed is partly a thin-bedded, rather sandy, syenitic gneiss, partly mica and hornblendic schist. The feldspar gradually disappears entirely in the schistose beds, which on weathered planes often have the appearance of a laminated sandstone. They include the principal jade-yielding rocks, being traversed by veins of a pure white, apparently zeolitic mineral, varying in thickness from a few to about forty feet, and perhaps even more. The strike of the veins is from north-by-west to south-by-east, or sometimes almost due east-and-west; and their dip is either very high towards north, or they run vertically. The mineral has the appearance of albite, but the lustre is more silky, or perhaps rather glassy, and it is not in any way altered before the blowpipe, either by itself, or with borax and soda. The texture is somewhat coarsely crystalline, rhombohedric faces being on a fresh fracture clearly traceable. It sometimes contains iron pyrites in very small particles, and a few flakes of biotite are also occasionally observed. This zeolitic rock is again traversed by veins of nephrite, commonly called jade; which, however, also occurs in nests. It is a white, tough mineral, having an indistinct cleavage in two directions, while in the other directions the fracture is finely granular or splintery, as in true nephrite. Portions of this mineral, which is apparently the same as usually called white jade, have sometimes a fibrous structure. This white jade rarely occupies the whole thickness of a vein; it usually only occurs along the sides in immediate contact with the zeolitic vein-rock, with which it appears sometimes to be very closely connected. The middle part of some of the veins and most of the others entirely consists of the common green jade, which is characterized by a thorough absence of cleavage, great toughness, and rather dull vitreous lustre. The hardness is always below seven, generally only equal to that of common feldspar, or very little higher, though the polished surface of the stone appears to attain a greater hardness after long exposure to the air. The color is very variable, from pale to somewhat darker green, approaching that of pure serpentine. The pale-green variety is by far the most common, and is in general use for cups, mouthpieces for pipes, rings, and other articles used as charms and ornaments. I saw veins of the pale-green jade fully amounting in thickness to ten feet; but it is by no means easy to obtain large pieces of it, the mineral being generally fractured in all directions. Like the crystalline vein-mineral, neither the white nor the green variety of

[1] Histoire de la Ville de Khotan, par A. Rémusat. Paris, 1820.

jade is affected by the blowpipe heat, with or without addition of borax or soda. Green jade of a brighter color and higher translucency is comparatively rare, and already, on that account, no doubt much more valuable. It is usually only found in thin veins of one or a few inches; and even then it is generally full of flaws.

The Belakchi locality is, however, not the only one which yielded jade to the Chinese. There is no reason to doubt the existence of jade along the whole of the Kuenlún Range, as far as the mica and hornblendic schists extend. The great obstacle in tracing out the veins, and following them when once discovered, is the large amount of superficial débris and shifting sand which conceals the original rock *in situ*. However, fragments of jade may be seen among the boulders of almost every stream which comes down from the range.

A great number of the better-polished ornaments, such as rings, etc., sold in the bazaar of Yárkand, have the credit of coming from Khotan; possibly they are made there by Chinese workmen, but the art of carving seems to have entirely died away, and indeed it is not to be expected that such strict Mohammedans, as the Yárkandees mostly are, would eagerly cultivate it.[1]

Since the re-conquest of the country by the Chinese in the year 1877, pieces of jade in small quantities find their way again to Peking, but nothing fit to be carved into large vases such as were turned out from the imperial workshops in the reign of Ch'ien-lung during the second half of the eighteenth century. This emperor was an enthusiastic patron of art workmanship, and most of the elaborately carved pieces of artistic jade which have found their way to Europe and America date from his time, many having been taken from the summer palaces at Yuan Ming Yuan in 1860. He was a poet, too, and proud of his penmanship, and would often have his verses in honor of some temple or bit of pretty scenery engraved in facsimile on jade tablets, to be mounted in a screen, or perhaps on a pair of teacups, with the magic seal Yü t'i, "imperial autograph," below. The remarkable round plaque of ivy-green jade, a foot across, in the Collection, No. 1188, is an example of this, being inscribed with an imperial ode on the Buddhist monk Bôdhidharma, who is represented crossing the waves, standing on a reed plucked from the shore, with the pilgrim's staff across one shoulder, having a book slung from the end, and the alms-bowl in his other hand.[2]

The inscription reads:

Upon a single reed floating over the waves,
Whether coming or whether returning,
With rapt gaze and hands folded in sleeves,
He bides tranquil and undisturbed.
As a means to cross the broad river,
A reed was sufficient for his power.
No other could perform such a deed,
We bow in adoration to the holy monk.
Yü t'i—"Composed and written by the Emperor."

On the other side of the same plaque we have a view of Golden Island (Chin Shan), near Chinkiang Fu, which stands out so picturesquely in the middle of the Yangtzĕ River near the mouth of the Grand Canal, covered with Buddhist shrines and monasteries.

The inscription, a rhyming verse of eight stanzas, reads:

The summit of the pagoda, crowned with its pointed spire,
Has the azure vault of heaven above, naught else stands so high.
The pilgrim sees here a peerless evidence of the sacred law of Buddha,
Which he cannot approach without feelings of awe and reverence.
Although the picturesque scene, the river and the hill, are the same as of yore,
We will venture to add to our old verses yet another measure.
Though in scholarly lore we cannot come near the poetry of Tung-p'o,[3]
Whose old rhymes we have borrowed once more to compose these stanzas.

[1] Report of a Mission to Yárkand in 1873, by Sir T. D. Forsyth. Calcutta, 1875. Chapter VIII, Geological Notes, by the late Dr. Stoliczka.

[2] Bôdhidharma, the twenty-eighth Indian and first Chinese Buddhist patriarch, the son of a king in southern India, came to China in the year A. D. 520, bringing with him the precious pâtra, the alms-bowl of Buddha, the prototype of the holy grail of Christian legend. He reached Canton on the twenty-first day of the ninth month, and after a short stay there came north to Loyang, the residence of the emperor of the Wei, a Tartar dynasty devoted to Buddhism. There he remained in silent meditation for nine years, hence receiving the name of the "wall-gazing Brahman," till his death A. D. 529.

[3] Su Tung-p'o, one of the most celebrated statesmen and poets of the Sung dynasty, flourished A. D. 1036–1101. The practice of composing new verses with lines ending in rhymes borrowed from old poets is a common intellectual exercise in China.

2.5

No. 364

VASE

(P'ing)

Ming Dynasty (1368–1644)

Jadeite

Below:

In the cyclical year *yi yu* (A. D. 1765) in the spring, during Our journey to the south, We ascended the Golden Hill (Chin Shan), climbed to the top of the pagoda and composed for the third time these stanzas ending with the same old rhymes as before. We also drew a sketch of the view, which We presented on leaving to the Temple Hall Miao Kao T'ang, to be kept there as a memento of Our enjoyment of the prospect.

Yü pi—"Penned by the Emperor," whose name follows in two square seals in antique script (Ch'ien Lung), the first character being engraved, the second cut in relief.

The mines of Upper Burma are the chief source of the white jade flecked with bright emerald-green, called *fei-ts'ui* by the Chinese, which is so highly prized by them and so largely imported for the manufacture of ornaments and articles of personal adornment. This is rightly identified by Pumpelly[1] with jadeite, which differs from nephrite in its greater specific gravity, as well as in physical structure and in chemical composition. The Chinese, although ignorant of the scientific difference, always distinguish the two minerals, and our author devotes the last section of his "Discourse" to this precious mineral. With all due deference to his disclaimer, it seems to occur also in the province of Yunnan,[2] although more sparingly than in Burma; and I think that the bowl of Ou-yang, alluded to, might well have been of this material, which is certainly hard enough to rub down pure gold if the surface be not perfectly polished.

The Chinese imitate this, as well as white jade, so successfully in glass, that it is almost impossible to distinguish a false bangle or ring by mere inspection, although they will give a different tone when struck by the finger-nail. The glass is peculiarly dense and heavy, and contains nearly half its weight of oxide of lead. It is somewhat inappropriately called *pâte de riz* by French writers.

Specimens of ancient jade are much sought after, and Section VIII of the "Discourse" is devoted to a description of the different varieties, of the curious conceits of the Chinese collector, and the affectionate way in which he cherishes the corroded piece, removes the rust, and brings to it a fine polish after months of patient effort. The idea that jade which has lain buried in the earth for over a thousand years becomes as soft as common stone is, of course, taken advantage of by the maker of false antiques, who will soak an object carved out of steatite in some colored decoction, and produce the most *recherché* aubergine-purple, hibiscus-yellow, or other tint hardly to be seen in true jade, and simulate the crackle of the most ancient porcelain in a way calculated to deceive the unwary. If the buyer remonstrates because he can scratch it with the finger-nail, he is told that this is only a test of its great antiquity. So Rémusat[3] relates that M. Bertin, who had, after a lengthened correspondence with the missionaries in China, gathered together so many precious materials to illustrate the arts and products of that empire, ought certainly to have possessed some objects carved in jade; and yet all things from his collection ticketed *yü* (jade) were really translucid steatites, a kind of soft stone that no one acquainted with the first elements of mineralogy could confound with jade.

Prehistoric jade implements are rare in China. I have seen only one arrow-head, which is in my collection in the Loan Exhibition at the South Kensington Museum. Jade celts of the perforated type are occasionally to be found in collections, and are known by the name of *yao chan*, medicine spades, being supposed to be relics of Taoist herbalists of olden times, and to have been used by them to dig up medicinal roots. They are often carved with an ornamental design in relief, to make ornaments to be worn on the girdle, not sufficiently to disguise the original form. Sometimes an ancient emblem of rank, such as used to be held in the hand of high officers at court ceremonies, is for sale at a prohibitive price.[4] Symbols were made of jade from the earliest times, for use in the worship of the powers of nature, heaven, earth, the four cardinal points, the sun, moon, and stars. They are still used in imperial worship, and there are six figured in the Govern-

[1] Geological Researches in China, etc., by R. Pumpelly. Smithsonian Contributions, No. 202, 1866, pp. 117, 118.

[2] The Yün Yü, or "Yunnan Jade," of the modern Chinese, considered by them a variety of *fei-ts'ui*, is a dark mottled-green, sometimes almost black, kind of jadeite, of high specific gravity. There are crude specimens in the London museums, presented by the late Colonel Guthrie. The jadeite ju-i (No. 523) is an example, though not so dark in color as some specimens.

[3] Recherches sur la Substance Minérale, appelée par les Chinois Pierre de Iu et sur le Jaspe des anciens. Suite de l'Histoire de la Ville de Khotan, par M. Abel Rémusat. 1820.

[4] Since the above was written I have received a water-color drawing of one of these ancient emblems, No. 317 in the Collection. It represents a *kuei*, or baton, of oblong shape with pointed apex, such as used to be held in the hands of a high official in full court dress. The surface seems to be corroded and much discolored—to a clouded dark reddish-brown tint in some parts. This word *kuei* is a very ancient character in the Chinese language, written at first without the radical *yü* (jade), which is now usually prefixed to the ancient form. It means primarily a baton or sceptre, and was given by the sovereign when he conferred a fief as a symbol of feudal rank, distinguishing the rank of the noble to whom it was given by differences in its form and length.

ment Statutes of the reigning dynasty quoted above. There are three round pi: the largest, Figure 1, over six tenths of a foot in diameter, perforated in the middle with a small round hole, of mottled "sky-green" colored jade, used in sacrificial worship on the Altar of Heaven and the Altar for Harvest Prayers; the next, Figure 2, two thirds smaller, made of clouded-reddish jade, for use on the Altar of the Sun, matching the porcelain sacrificial vessels and libation-cups, which are covered with red glaze; the third, Figure 3, thirty-six hundredths of a foot across, pierced with a square hole in the centre, made of pure white jade, matching the white porcelain, for use on the Altar of the Moon. The yellow tsung, Figure 4, for use on the Altar of the Earth, is carved out of yellow jade, with square base four tenths of a foot across, and rounded top, marked at one of the corners with natural lines in the form of a range of mountains. There are two kuei, also illustrated here, each thirty-six hundredths of a foot in diameter, of square section, with a small process (*ti*) projecting on either side; one, Figure 5, rounded above and below, of white jade, with a faint yellowish tinge; the other, Figure 6, flattened, made of green-colored jade—both used in sacrificial worship on the Altar of the Land and Grain.

In ancient times these jade symbols used to be buried in the earth, offering a certain analogy to the round stone "whorls," with inscriptions, found in such large quantities by Schliemann in the ruins of ancient Troy, the use of which has so puzzled archæologists. The peculiar "cash" of the Chinese, which has circulated some three thousand years, is said to be modelled on the same lines, its round circumference symbolizing the vault of heaven, its square hole in the centre, the earth.

Jade has often been used in the manufacture of talismans and amulets, and in Chinese collections of antiquities we find certain small round or octagonal cylinders, which have a remarkable resemblance to the ancient cylinders inscribed with figures and inscriptions of Babylonian, Assyrian, and Persian origin, like the well-known signet cylinder of King Urukh of Chaldea, found by Sir R. Porter, and copied by Professor Rawlinson,[1] from his Travels.

It is recorded in the official annals of the period that signets of this kind were worn, attached by silk cords strung with pearls and precious stones, to the girdle of the official costume of the mandarins during the Han dynasty, which flourished two centuries before and after the Christian era. The Annals of the After Han describe those of princes and nobles to have been made of white jade; those worn by officers with annual salary of two thousand to four hundred piculs of rice, of black rhinoceros horn; officers of lower rank, private scholars, and students wearing ivory signets. They were made on the cyclical day *mao* of the first moon, and were hence called *kang mao*. They were abolished temporarily by the usurper Wang Mang, in the year A. D. 11, for a superstitious reason, the character *mao* forming part of the character *Liu*, the family name of the Han.

The specimen before us, No. 331 of the Collection, is an octagonal cylinder, two inches long, engraved with four characters in antique script on each of its faces, the whole inscription being like this when spread out:

May this amulet of the day *mao* of the first moon,
With miraculous power pervade the four quarters,
That the red, blue, white, and yellow,
All four colors may be duly harmonized.
May the charm recited by imperial order,
To instruct the dread monsters and dragons,
Be efficacious in all dangerous diseases,
Which I could not dare to withstand.

The Chinese are so devoted to researches into antiquity, and have published so many books on numismatics, ancient bronzes, sacrificial vessels and implements, old inscriptions, and kindred subjects, that we naturally expect to find a series of special works on jade. The absence of such works would show the rarity of ancient specimens of jade. One of the most celebrated books on bronze antiquities is the "Po ku t'ou," in thirty books, written by Wang Fu in the beginning of the twelfth century, in which several hundred vessels are figured, with a facsimile of the inscription upon each. A revised edition was published

[1] Rawlinson's Ancient Monarchies, Vol. I, p. 94.

during the Yuan dynasty, in the Chih-ta period (A.D. 1308–11), in large folio, the vases being represented of the original size. I have in my possession an incomplete copy of this last edition. New editions were issued during the Ming dynasty, in the seventh year of Chia Ch'ing (1528) and in the cyclical year *kuei mao* (1603) of the reign of Wan Li. Of more recent editions one of the best is that edited by Huang Shêng, published in the eighteenth year of Ch'ien-lung (1753). The same scholar edited at the same time another illustrated collection of antiquities of about one third of the extent of the "Po ku t'ou," called "K'ao ku t'ou," in ten books, by Lü Ta-lin, first published during the Sung dynasty, in the seventh year (1092) of the Yuan-yu period (1086–93). This is more interesting to us, because the eighth book comprises a small collection of jade in the possession of Li Po-shih, a native of Lu-chiang, including a tiger-shaped tablet, scabbard-guards, a round symbol, girdle buckles and appendages, a double-handled wine-cup engraved with spiral ornament, etc.

With this edition of the two books on ancient bronzes there is usually bound up at the end another work, entitled "Ku yü t'ou" ("Illustrations of Ancient Jade"), in two books, by Chu Tê-jun, introduced by the same editor, Huang Shêng, in a preface, also dated 1753. The original introduction by the author, who flourished during the Yuan dynasty, is dated the first year of the period Chih Chêng (A.D. 1341). He says that "from the time he left college he used to visit the houses of the princes and celebrated men of the capital city of Yen (the modern Peking), as well as the collection in the imperial palace, and examine carefully the different objects, so as to appreciate the excellency of the things worn and vessels fashioned by the ancients, and to figure a few examples of such as had survived, and which he had seen himself, to present to those who take an interest in the study."

The most curious relic of jade-carving figured in this volume is the first, entitled "Apparatus for South-pointing Chariot," which is described thus: "The chariot apparatus figured above measures in height 1.42 feet, and is .74 of a foot in length below. The man's figure, carved out of jade, has one hand constantly pointing towards the south, the bottom of the foot being drilled with a round hole, so that it turns upon a pivot, poised on the head of the fabulous monster Ch'i-yu.[1] In the period Yen-yu (1314–20) I succeeded in getting a sight of this at the Imperial Decree Office of Yao Mu-an. The color of the jade had a yellowish tint, mingled with bright red of antique shade, and it had marks of erosion from having been buried in the earth." The south-pointing chariot is said by Chinese commentators to have been invented by the ancient emperor Huang Ti, and to have suggested the invention of the mariners' compass, which is always called by them the south-pointing needle.

The next figure is that of a round medallion, *pi*, a foot in diameter, with a round hole in the centre surrounded by a zone of spiral ornament, and, outside, a second zone of interlacing dragons. Next follow in order sword-clasps, round ornaments in the form of coiling lizards, and girdle-buckles of varied designs.

The second book contains figures of insignia of rank, ornaments for the girdle and for the ears, a piece of jade in the form of a cicada from the mouth of a corpse, a winged monster said to have been dug up by a peasant from the grave of the ancient king T'ai K'ang and bought from him by imperial command by Chao Tzü-ang to be used as a letter-weight, jade horses, girdle buckles, a wine-cup of form and design similar to the one in the other collection of Li Po-shih mentioned above, ornaments for scabbard, and a sword-handle.

These are, however, but meagre collections of small extent compared with that contained in the one special book on the subject, which is entitled also "Ku yü t'ou," or, in full, "Ku yü t'ou pu" ("Illustrated Description of Ancient Jade"). This is the catalogue, in one hundred books, with more than seven hundred figures,

[1] A legendary being generally considered to be the first great rebel, who sought to overthrow the ancient emperor Huang Ti, and the reputed inventor of warlike weapons. Some pretend that he was the head of a confederacy of eighty-one brothers, who had the bodies of beasts, but human speech, with foreheads of iron, and who fed on the dust of the earth. His spirit is believed to reside in the planet Mars, which influences the conduct of warfare. See Mayer's Chinese Reader's Manual, p. 36.

of the collection of jade belonging to the first Emperor of the Southern Sung dynasty, who had resigned the empire to his son in the year 1175, the year before it was published by an imperial commission of nineteen members, including one writer and four artists, presided over by the President of the Board of Rites, Lung Ta-yuan, the author of the original preface, which reads thus:

His Majesty the Great Exalted Glorifier of Yao, the Sacred Emperor, endowed by Heaven with love for antiquity, and therefore fond of searching the ancient records, reposing from the toils of state, one day quoted to us the Annals of Ch'u, which say that, "The Ch'u State had nothing which they deemed precious, it was only virtue which they thought precious." Therefore what is there in old curios to be fond of? Yet to perfect knowledge it is necessary to study the real things, is what the sacred classics teach us most clearly. The sacrificial vases like the *ting, yi, tsun*, and *lei*,[1] are important vessels, and these have all been described in the "Po ku" and "K'ao ku" books. But the largest of these bronze vessels are big enough to hold an ox, and even the smallest to contain a good-sized measure of grain, so that very few could be carried in the girdle pocket or placed upon the side-table. For those who like to take things away in their sleeves, handy to be caressed, and easily carried about, only pieces of ancient jade are available. Therefore from the complete collection of specimens preserved in the imperial palace, when resting from a myriad affairs, he orders his near attendants to bring some out to rejoice his eyes. His Majesty the Great Exalted Sacred Emperor, of supernatural wisdom and celestial genius, and naturally endowed with knowledge of things, although he allows his mind some distractions in leisure hours, yet he is not lost in a mania for curios, but consults the classics as mirrors of antiquity to perfect his sacred scholarship.

He has lately, wearied with the weight of affairs of state, resigned the throne, and stays highly reverenced in the celestial palace. His Majesty the Reigning Emperor, rivalling Shun of Yü in filial piety, and equal to Yao[2] of T'ang in power, waits upon His Majesty the Great Exalted Sacred Emperor, a model to his family and state, holding the whole world in trust for his delectation, so that of all the precious things that can feast the eyes, there is nothing that he does not search out and reverently offer. So His Majesty the Emperor himself, when tired with toil, has rested awhile at the T'ang-t'ing pavilion, and during his visits there has compiled a full description of the rare pieces of precious jade belonging to various dynasties. Yet he is not satisfied with its completeness, and he has commissioned his officers to take silver and select more pieces, and has acquired altogether more than seven hundred specimens, which he has reverentially presented to the Tê shou kung, to be kept there as pure ornaments for the side-tables of His Majesty the Great Exalted Sacred Emperor.

He has accordingly commissioned us his servants, Ta-yuan and his colleagues, to arrange them in proper order, to collect artists in color to draw the different forms, to state the exact dimensions, to make careful quotations from books, and to write a complete description of each piece.

His servant has heard that the scholars of olden times likened jade to virtue, because dirt would not stain it, nor friction injure it, because it was of liquid aspect yet brilliant, of warm appearance yet strong. So from the Three Dynasties to the present day, all the important vessels of the Ancestral Temple and all the chief treasures of the imperial court have been fashioned out of fine jade. From the Son of Heaven down to the hereditary princes and high officers, all carried or wore jade in the form of *kuei, chang, huan, pi*,[3] and the like, each denoting a particular purpose and not used solely for ornament. Learned scholars of after times carefully explore dark caves and search the recesses of mountains, sparing neither silver nor silks to buy these at large prices. As soon as a specimen is acquired they distinguish its workmanship and design and trace out its model and form, both telling of the different colors of the jade and of the details of the carving. Though buried in deserted ruins, or thrown away in old pits, yet they have not been lost, but after having long lain hidden during thousands or hundreds of years, have one day been recovered by the world, to be passed from hand to hand as presents, so that precious jade has also its periods of light and darkness fixed by fate.

Your servant, reverently obedient to the special command, has collected a body of officers, who, after extensive research into antiquity, reference to the classics and other books, have figured the specimens, painted them in color, and written a description of each. The exact dimensions of the pieces and the presence or absence of spots and other colors are all duly described, so that it is only necessary to open the leaves to see everything at a glance, and to know the dynasty and the class of vessel. The jades in the collection have been enclosed, as it were, in a casket, where there is no fear of their being broken, and they can be seen by merely unrolling the scrolls, so that after readers may be appealed to, to attest the truth of my words.

So your servants, Ta-yuan and his colleagues, though their knowledge is not sufficient to paint the whole ox, nor their scholarship to include the two sides of the leopard, have, reverentially honoring the imperial order, ventured to try to carry out the task, and have compiled this "Ku yü t'ou pu" in one hundred books, which they reverently offer in the imperial palace, in the fond hope that His Majesty the Emperor, when free from the myriad affairs of state, may lend his light-giving glance, so that his servants may be honored with his unbounded grace and be rendered exceedingly joyful.

First day of third month of third year of Ch'un-hsi (A. D. 1176).

[1] These vessels were anciently cast in bronze. The *ting* is a caldron with two handles or ears, either of rounded body with three legs, or of oblong form with four legs; it was originally a cooking-vessel. The *yi* is a flat-bottomed vessel, without feet, for holding sacrificial millet; the *tsun*, a trumpet-mouthed vase for holding sacrificial wine; and the *lei* is also a vase for wine, engraved with cloud-scrolls and similar designs from which it got its name. The old forms are copied in the present day in porcelain, jade, etc., as well as in metal. The Buddhists have adopted the *ting* as an incense-burner and the *tsun* as a pair of flower-vases for their altar set.

[2] Yao is the designation of the Great Emperor, who, with his successor Shun, stands at the dawn of Chinese history as a model of all wisdom and sovereign virtue. After occupying the throne for seventy years, he set aside his unworthy son Tan Chu and selected the virtuous Shun as his successor, giving him his two daughters in marriage, and abdicating in his favor. Shun adopted the great Yü as his successor, the founder of a hereditary line, the first of the three ancient dynasties, whose reign is said to have begun B. C. 2205.

[3] The different forms of these jade antiquities are illustrated in the subsequent pages of the book. The *kuei* was an oblong tablet or baton

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No. 446

SCEPTRE

(*Ju-i*)

K'ang-hsi (1662–1722)

Nephrite

After the preface there is a list of nineteen names, giving the members of the commission with all their titles and honors, including one writer, and the four artists, Liu Sung-nien, Li T'ang, Ma Yuan, and Hsia Kuei, who are all included in the large catalogue of writers and artists published in the reign of K'ang-hsi.

The second preface, by Chiang Ch'un, dated the forty-fourth year of Ch'ien-lung (A. D. 1779), relates how "a manuscript copy of the book had been purchased in 1773, when the Emperor had issued a decree to search throughout the empire for lost books, and a copy sent to be examined by the library commission then sitting. This year I again read through the original manuscript and found the descriptions clearly written and the illustrations cleverly executed, so that it was worthy of being compared with the 'Hsüan ho Po ku t'ou.' This book describes the ancient bronzes referred to in the Rites of the Chou dynasty, while our work describes the jade, so that we could not spare either. The 'Po ku t'ou' was reprinted several times and gained a wide circulation, while this book remained in manuscript and attracted no notice, not being included in the Catalogue of Literature of the Sung History, nor quoted by older writers. Lung Ta-yuan, whose name is included in the chapter on Imperial Sycophants of the Sung History, died before the date of publication, but he is left at the head of the commission, in memory of the work done by him. His actions were not worthy, but that is no reason for suppressing his book. I venture to bring this book before the eye of the Emperor, that it may again be referred to the library committee for revision and be corrected by them, and have the honor of being reprinted under special imperial authority."

The verdict of the library committee seems to have been unsatisfactory, for they criticize the book most severely in the Imperial Catalogue ("Ssŭ ku ch'üan shu tsung mu," Book 116, folios 7–9), on account of there being no references to it in later books, and of certain anachronisms in the list of members of the commission, and declare it finally to be a fraud and not even a clever one; without any examination, however, of the contents. In consequence of this adverse decision, the book, in spite of the appeal in the preface, was not reprinted with the imperial imprimatur, and it has now become very rare. The illustrations, at least, seem to date from the Sung dynasty and to represent the imperial collection of the period, several of the pieces being inscribed on the back as having belonged to the T'ang and Southern T'ang dynasties, which flourished before the Sung. The collection is distributed under the following classes:

1 State Treasures (Kuo pao), Books 1–42
2 Amulets or Talismans (Ya Shêng), Books 43–46
3 For Chariots or official Dress (Yü fu), Books 47–66
4 For use in the Study (Wên fang), Books 67–76
5 For burning Incense (Hsün liao), Books 77–81
6 Drinking-vessels (Yin ch'i), Books 82–90
7 Sacrificial Vessels (Yi ch'i), Books 91–93
8 Musical Instruments (Yin yo), Books 94–96
9 Decorative Furniture (Ch'ên shê), Books 97–100

The first class includes the tablets and insignia of rank worn in former times by the emperor and high officers, symbols of worship, state seals, and medals. It begins with two oblong tablets over a foot long, with two undecipherable characters on the face of each, attributed to the ancient emperor Yü Wang, from the resemblance of the characters to those of the inscription from the Ku-lou Mountains.[1] They are described as having been discovered in two bronze tripod urns, weighing about one hundred and fifty pounds each, during the period Chih-ho (1054–55), in the dried bed of the Chi River, and were supposed to have been put into the river during the T'ang dynasty as offerings to the river-god, being inscribed on the reverse side in antique script: "Black kuei of Yü Wang when he removed the waters. Precious specimen preserved in the Treasury of K'ai-yuan (713–741) of the Great T'ang [dynasty]."

Many other tablets follow, but they have little pretension to the great antiquity assigned to them, and some of the inscriptions are evidently copied from pieces of ancient bronze figured in archæological books;

of rank coming to a point above; the *chang*, half a *kuei*, divided longitudinally. The *huan*, originally an armlet of stone, was a solid ring; the *pi*, a circular tablet pierced with a hole in the centre. These last were most highly valued in feudal times in China, and cherished as the palladium of the principality, so that a single *pi* would ransom several walled cities. When circular metallic money was adopted as currency in China, during the Chou dynasty, the first bronze coins were cast in the form of the ancient jade *pi*.

[1] Given in Legge's Chinese Classics, Vol. III, p. 73.

and, in fact, many of the specimens in the later parts of the collection seem to be derived from a similar source—the fountainhead of almost all Chinese decorative art.

The symbols used in imperial sacrificial ceremonies come next, a long series of round, square, octagonal, and diverse form. The round symbol, *pi*, twenty inches in diameter, drawn in Book 14, folio 11, like that used in the Han dynasty when the emperor prayed for rain in time of drought, has a three-clawed dragon coiled round the central hole, an antique model of the modern Japanese dragon.

In Books 25 and 26 are the tiger-shaped tablets worn by high officers in the Han dynasty, types of the gold and silver tablets of authority described by Marco Polo, and figured in Yule's beautiful edition of his travels. Books 27 and 28 contain libation-ladles and ceremonial weapons copied from ancient bronze implements. The next two books comprise sword-hangers and mounts, scabbard-guards and ornaments, halberds and maces.

The eight following books are filled with a long succession of imperial seals, beginning with the famous palladium seal of the first emperor of the Ch'in, the builder of the Great Wall of China in the third century B. C., the possession of which conferred succession to the empire, hence its name of "Ch'uan kuo hsi." The seals of the Han dynasty, which succeeded him, are square, with elaborately carved handles in the form of dragons and other monsters, interlacing rings, elephants, and fabulous birds. The seals of the T'ang are of similar shape, surmounted by handles of spotted deer, elephants, tortoises, etc. Seals of the dynasty then reigning, the Sung, occupy Books 35–38. These are of varied form, with handles of ch'i-lin, fishes, lions, or intricately coiled dragons, sometimes decorated all over with engraved dragons and phenixes. The description of two of these may be extracted. The first, a square seal figured in Book 37, folio 7, with a well-designed horse standing upon it tied to a ring in a post, to serve as a handle; the inscription graven in relief on the lower face being illustrated separately. "The above seal, twenty-four hundredths of a foot square, thirty-one hundredths high, with handle in the form of a dragon horse, is of jade of translucid white color without spot. The inscription, in four characters of antique script, reads: 'Seal of imperial autograph.' This is the seal that was always used by the Emperor Hui Tsung (1101–25) when he wrote an autograph despatch to one of the princes or nobles, or to a foreign country. The handle is said to have been carved by the clever craftsman Wang Yu; the horse is modelled with rare skill, and is instinct with life, an inimitable piece of work." The second, figured on folio 12 of the same book, is a square seal surmounted by a unicorn, and is described: "The above seal is twenty-five hundredths of a foot square, twenty-six hundredths high, with handle carved in the form of a fabulous unicorn. The color of the jade is pure green without flaw. The inscription, in four characters of antique script, reads: 'Seal of Fêng hua t'ang.' This, meaning 'Hall of respectful beauty,' is the name of the abode of the Second Consort of His Majesty the Great, Exalted, Glorifier of Yao, the sacred, long-lived Emperor, a scion of the Liu family. This consort is learned, accomplished, and virtuous, and is known within the palace as Our Lady Liu.[1] She is a skilled writer and artist, and whenever the retired Emperor has occasion to reply to any official, he generally directs this lady to write the answer in the style of the Emperor's own handwriting. The seal is that usually used by the Second Consort upon her own private letters and paintings." The next book contains small private seals of the Sung emperors, of curious design, one in the form of a round box with engraved scroll border, and a handle like a "cash" of the period, with a pair of birds and two fishes on its rim, inscribed "Hsüan-ho nien chih," made in the period Hsüan-ho (1119–25). The seal of two characters, formed to look like a pair of dragons, reading "T'ien shui," celestial waters, was used by the emperor Hui Tsung on his autograph letters and paintings.

Books 39 and 40 contain a series of jade tablets, with inscriptions, belonging mostly to the Han dynasty. Books 41 and 42, a collection of jade medals with lucky inscriptions, "out of a box in the Treasury, over two feet long, half as much broad, and nearly a foot high, full of different kinds of jade medals, dating from the Han and T'ang dynasties. This box, made of solid silver, was inscribed on one side with the date Shun-hua (990–4), when it was got by the emperor Tai Tsung, the second of the dynasty, after the conquest of Mêng, the ruler of Shu (modern Ssŭ-ch'uan)."

[1] There is a short biography of this lady in the official annals, Sung Shu, Book 243, folio 14, which tells us that she was promoted to be Second Consort in 1154, and died in 1187. She was fond of luxury as well as accomplished, and had a foot-stool made of rock-crystal for summer use, which the emperor took for a pillow, and this so mortified her that she threw it away. That her seal should be included is evidence of the authenticity of the collection. Such "hall-marks" are still used to seal imperial verses written in the halls or pavilions, as well as on porcelain services made for use in them.

The amulets included in the second class are contained in Books 43–46, which comprise oblong pieces with Taoist deities and serpent handles, and others in the form of ancient sword-money, reproductions of ancient coins of different shapes; medals with appropriate legends given to princesses on their marriage to hang on their bed-curtains, and others as gifts to babies at their first ceremonial bath; concluding with the signets worn at the girdle by high officials of the Han dynasty, with inscriptions of similar purport to that given above.

The third class begins with a jade figure from a "south-pointing chariot," followed by carved mounts for the end of shafts, tires of wheels, hooks for the reins, and other ornaments from imperial chariots. Books 49–51 give a selection of ceremonial caps or crowns, all transfixed by a jade pin to fasten them to the hair. The empress's crown of ancient jade, figured last, reminds one in general outline of a European crown. It is interesting as an early example of jewelled jade, and is described as over a foot high, made of bright-green jade, with upright lobes carved in the form of cloud-scrolls, inlaid with pieces of yellow, red, green, and white jade, and incrusted with pearls, corals, and precious stones, as well as divers colored glass, so that its brilliancy is truly dazzling, and declared to be a rare and priceless relic of the Han or Wei dynasty. Other jade objects, worn on occasions of ceremony, follow in order. Girdles, inlaid with ornamental plaques of jade, the parures of jade ornaments, beads, and chains that used to be suspended from the neck, and detached ornaments from the same, girdle-rings, fasteners and buckles, pins for the hair, ornaments carved in the form of a pair of fish, phenixes, or coiling lizards, a cicada, or a tiger, ending with a well-designed *Bignonia* flower three inches long of natural red jade, leaves of green jade carved out of one piece with such skill as "only a clever artificer of the Han could show."

The furniture of the scholar's study, which forms the fourth class, fills ten books. Of the ink-pallets, the first one illustrated, with its scroll border and elephant engraved on the back, the outline of which is like that of a vase with loop-handles, is an exact counterpart of the ink-pallet of imperial porcelain of the Sung dynasty, No. 8, in the old album described by me.[1] Some of the others are of graceful design, like the double gourd, with leafy branch and tendrils for a handle, and a tiny gourd for a trench to hold the water, and the pallet shaped like a lotus-leaf with uptilted rim. A curious ink-pallet is drawn in Book 68, folio 9, a circular plaque of black and white jade over a foot in diameter, the two colors separated by a sharply defined curved line, so as to form a natural symbol of the Yin-yang, the mystic female and male principles, separating as in the primordial chaos molecule. It has on the back an inscription of fifty-six words in verse, to the effect that it was sent to the emperor as a tribute gift from the West.

Next come cylindrical handles and tubes for the hair-pencil, plain, with scroll borders, or engraved with dragons. One is inscribed on the handle, "Upright heart makes upright pencil"; on the tube, "Chien yeh wên fang," the name of the study of Li Yo, the last sovereign of the Southern T'ang, who was dethroned in 975, so that it must have originally belonged to him.

Pencil-rests follow, in the forms of hills and natural rocks. Then water-bottles, little bowls, and water-droppers; some of the first-named of elegant design, like the dragon-handled vase in Book 71, folio 7, the body of which is decorated with cloud-scrolls, the shoulder and neck with leaf borders, the foot and rim with pearls; others in the form of animals, as a goat or duck, a toad or tortoise, or of plants, like the lotus or musk-melon. Then letter-weights, foot measures, and ornaments for the table, ju-i of jewelled jade[2] set with rubies and other precious stones, chowry (fly-brush) handles, body-scratchers of quaint form and design, and lastly a Buddhist rosary with one hundred and eight beads.

The urns or censers for burning incense and fragrant wood, which constitute class 5, are distributed through five books, and are all modelled on ancient bronze designs. So are most of the wine-vessels and wine-pots, libation-cups and drinking-cups figured in the next nine books. An exception to this general rule

[1] Chinese Porcelain before the Present Dynasty, by S. W. Bushell, M.D. (Peking Oriental Society, 1886), p. 13. A wine-pot of Hsüan-tê (1426–35), No. 40 of this album, of deep-red porcelain, and described as copied from a jade wine-pot of the Han dynasty used by the emperor, is exactly similar in form and design to two of the wine-pots figured in the Ku yü t'ou, which are attributed to the same date.

[2] The ju-i is a magic wand often placed in the hands of Taoist divinities. It seems to have been originally a branch of the woody colored fungus, *Polyporus lucidus*, an emblem of longevity, often met with in Chinese art. The name is composed of two characters meaning "as you wish," and must be distinguished from *jui*, a monosyllable meaning tablet or baton, which is used as a general term to include the *kuei* and other ancient badges of feudal rank. A jade ju-i mounted with jewels was included among the presents sent by the Emperor of China to Queen Victoria in the fiftieth year of her reign, and one is often sent to a high mandarin on his sixtieth birthday or other auspicious occasion.

is the wine-vessel in Book 90, folio 5, modelled in the form of a horned dragon of fierce aspect, with scaly body, 1.65 feet long, hollowed out to hold the wine, which is poured in at the top of the head, and flows out when the cap is taken off from the end of a spout hidden under the tongue. "The hair and beard are carved fine as silk, the eyes are constructed so as to move in hollowed sockets, and the white translucid jade of the scales made so thin that the red color of the wine shines through. This rare and valuable present was sent by the king of Khotan as tribute in the period T'ien-shêng (1023–31), and has been placed among his greatest treasures by each successive emperor of our dynasty down to the present." The sacrificial vessels of class 7 include wine-receptacles of diverse form and tazza-shaped round dishes for other offerings, also made after antique bronze designs.

The musical instruments of class 8 include what may be described very closely as guitars, bells, sounding-stones, mouth-harmoniums, pandean pipes and flutes, drums of different kinds, clappers of five pieces hung on a string, and stringed instruments of various shapes.

The ninth and last class opens with a short series of Buddhist and Taoist figures and scenes, engraved on oblong plates of jade between two and three feet long, including a carved image of the god of longevity. A representation of Amida Buddha, seated with staff and rosary, is engraved within a medallion on the first plate, dated Pao-ta (943–957).

The next, an irregular four-sided plaque of pure white jade over two feet in height and breadth, has upon it an image of Samantabhadra, one of the great saints of the Tantra school of Buddhists. The figure, seated on a mat, with a flower-vase on its left and an alms-bowl on the right, in the midst of rocks enveloped in clouds, is said in the description to have been miraculously produced, not carved by mortal hand. The empress mother of Shên Tsung, the fifth ruler of the Sung dynasty, who was an ardent devotee of this saint and of the goddess Kuan-yin (Avalokiteshvara), commissioned one of the chamberlains named Kao K'an to burn incense to them in the cave Hu Yin Tung. From this cave, one day in the year 1068, came sounds of thunder and a torrent of water bringing with it this sacred image, which Kao K'an carried in all haste to the empress, who placed it with much ceremony in a shrine within the palace for her own worship.

Another medallion-picture, carved on light-green jade, of "Samantabhadra Washing the Elephant" is inscribed as drawn after the artist Yen Li-pên of the T'ang dynasty, by the worker in jade P'êng Tsu-shou, to be presented by the imperial treasury of K'ai-p'ing (907–910) of the Great Liang to the Buddhist monastery Hung Ming Ssŭ. K'ai-p'ing was the title usurped by Chu Wên, a rebel who flourished in the ninth century at the end of the T'ang, till he was stabbed by his son. The pictures of the god of literature and of the ancient emperor of the East with their attendants are inscribed with the names of the carvers, one of whom, Wang Yu, already alluded to, belonging to the Imperial Jade Manufactory of the Sung emperor.

The first of these two deities, Wên Ch'ang Ti Chun, whose celestial abode is in the Great Bear, is represented seated on a mule riding upon the clouds, with two attendants on foot, one carrying the ju-i sceptre, the other a lyre wrapped in silk. The second, Tung Wang Kung, the Lord Sovereign of the East, one of the most famous divinities of Taoist legend, was the husband of Hsi Wang Mu, the Western Royal Mother, the queen of immortals, who dwells on the K'un Lun Mountains in a magnificent palace, on the borders of the Lake of Gems, beside which grows the peach-tree of the genii whose fruit confers immortality. In the Sung dynasty a mystical doctrine representing this pair as the first created and creative results of the powers of nature was elaborated. The god, holding a scroll in his hand, is seated here before a tripod urn preparing the *elixir vitæ* from vermilion, with two attendants standing near, one bearing the ju-i sceptre, the other a basket of peaches. Both of these works of art are dated the second year of the Hsiang-fu period, corresponding to A.D. 1009.

Then come jade pillows, one of four-sided oblong form two and a half feet long and nearly a foot across, with scroll borders made of translucent white jade with a slight tinge of green, engraved all over with dragons and phenixes in clouds fine as silk, said to be a relic of the palace of the T'ang. Then shoulder-rests for the divan, like small tables, and boxes carved in openwork for holding fragrant flowers or perfumes.

Book 100 contains the largest specimen in the collection, an oval vase (*wêng*) figured on folio 3, and described as 4.4 feet high, 7.2 feet in circumference at the body, 3.6 at the mouth, of translucid white color, with moss-green marks and spots of brighter emerald-green. It is engraved with three-clawed dragons in pursuit of pearls emerging from sea-waves and surrounded by clouds, which show out the rare green tints of the

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No. 604

PILGRIM BOTTLE

(*Pei Hu P'ing*)

Ch'ien-lung (1736–95)

Nephrite

H. GUERARD SC.

ground. When filled with wine it held about eighty pints. It is described as the largest known jade vessel and of perfect workmanship, a unique relic of the Chin or T'ang dynasties. Among the other pieces figured here are a large fish-bowl (*kang*), 3.6 feet high, 6.4 feet round, decorated with fishes and dragons; square flower-pots; round and foliated saucer-shaped dishes for holding flowers; a circular deep dish with four legs, for iced melons or sliced fruit in summer, etc., the last illustration being that of a plain round bowl of simple antique design of beautiful emerald-green jade without flaw.

But it is time to turn to the consideration of modern artistic work in jade. The principal workshops are at Peking, where, however, only small articles of daily use, such as snuff-bottles, mouthpieces for pipes, beads for the mandarin's rosary, rings, and other objects of personal adornment are turned out in the present day. I persuaded a Chinese artist to visit some of them and take sketches of the different processes of work and of the tools employed in working into shape the rough material, carving and polishing it to its perfect form. He found much difficulty at first, as the suspicious craftsmen were convinced that he was only anxious to worm out their secrets for his foreign friends to improve the tools and gradually supplant their work. At last, however, he fell in with one more amenable to reason, invited him to the theatre and to a good dinner afterward, at which he made his notes, and arranged for a tour of the workshops next day. The results of his visits are embodied in the twelve pictures, which, with my translation of the descriptions of the artist, Li Chêng-yuan, follow Mr. T'ang's "Discourse on Jade," which immediately follows this Introduction.

The Chinese artist, Li Shih-ch'üan, *i. e.*, Petrus Li, Chêng-yuan being his artistic designation or *nom de plume*, calls his article "Yü Tso T'ou" ("Illustrations of the Manufacture of Jade"), and introduces the water-color illustrations by a short preface accompanied by a table of contents, which I will translate in due order. The artist's Chinese preface occupies the middle of the first page, and must be read in vertical lines, from right to left. The table of contents is written on the pink ground on either side of the same page. The first two processes—(1) "Pounding the Sand" and (2) "Grinding the Sand"—are combined in the first picture, so that the thirteen in the list contained in the table of contents make only twelve illustrations altogether. The artist, with Chinese industry and perseverance, has painted a sufficient number of pictures for the whole edition, so that every one of the illustrations is an original water-color production of his brush.

YÜ-SHUO

A DISCOURSE ON JADE

WITH RESEARCHES ON THE HISTORY OF JADE

BY

T'ANG JUNG-TSO

Styled "Hsi-wu"

CITIZEN OF PEKING

GRADUATE AND SCHOLAR OF THE CHINESE EMPIRE

TRANSLATED BY

STEPHEN W. BUSHELL

YÜ SHUO

A DISCOURSE ON JADE

WRITTEN BY

KU YU HSÜAN CHU JÊN

DWELLER IN THE "HALL OF ANCIENT RARITIES"

SEALED WITH HIS LIBRARY SEAL

"KU YU HSÜAN YIN"

IN THE CYCLICAL YEAR KÊNG YIN OF THE
EMPEROR KUANG HSÜ

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I Sources of Jade
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III Value of Jade
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VII Colors of Jade
VIII Ancient Jade
IX Fei-ts'ui

and

An Appendix containing the Titles of
Seventy-one Books quoted
in the Text

福祿壽玉插屏圖

No. 731

SCREEN

(Ch'a P'ing)

Wan-li (1573–1619)

Nephrite

43

YÜ SHUO

I. SOURCES OF JADE

THE magic powers of heaven and earth are ever combining to form perfect results: so the pure essences of hill and water become solidified into precious jade. Hence all the places which produce jade are situated in the midst of mountains and streams. A short account of these may be gathered from different books.

The "Book of Annals" ("Shu Ching"), in the "Tribute of Yü,"[1] records that the province of Yang-chou sent as tribute *yao* and *k'un* stones, bamboos small and large, etc. The Commentary says that *yao* and *k'un* were both precious jades. Also that the province of Liang-chou sent as tribute *ch'iu*, iron, silver, stone for arrow-heads, and musical stones. The Commentary says that *ch'iu* were musical stones of jade. Also that the province of Yung-chou sent as tribute *ch'iu*, *lin*, and *lang* and *kan*, precious stones. The Commentary says that the *ch'iu* and *lin* were fine jades and could be used to make the symbols of rank called *kuei* and *chang*.

The "Rites of Chou" ("Chou Li"), in its Geographical Section, says that the region due west was called Yung-chou, and that its commerce was in jade and stones. The "Book of Rites" ("Li Chi") says that rocks which contain jade have a vapor like a white rainbow beside them, its pure essence becoming visible in the mountains and streams. The "Po wu chih" says that the hills on which millet grows produce jade; Huai Nan Tzŭ, that streams which have round bends contain pearls, those with angular bends jade. An illustrated book on jade mirrors ("Yü ching t'ou") says that when, in the second month, the plants growing on the hills have a light hanging down from them, there is jade; the spirit of jade being like a beautiful girl. Another book on jade ("Yü Shu") says that jade has markings on it like dark hills or like green waves; that when it occurs in mountains the trees are luxuriant; when it is produced in rivers the water is fertilizing; and that although hidden in the rock, its variegated colors shine through.

From these various quotations it may be seen that there are two kinds of jade—the one found on mountains, the other in rivers. In China proper jade is generally found in the hills, while in Khotan (Yü-tien) it occurs usually in rivers. The Materia Medica ("Pên Ts'ao"), quoting Hung-ching (A. D. 452–536), says: "The best jade comes from Lan-t'ien, also from Nan-yang, and from the Lu-jung river in Jih-nan; that brought from the foreign countries of Khotan (Yü-tien) and Kashgar (Su-lê) is also good. If translucent and white as hog's lard, and resonant when struck, it is genuine. The counterfeits have many points of resemblance and must be carefully distinguished." The "Yi wu chih" says that jade comes from the K'un-lun Mountains. The "Pieh pao ching," that rocks which contain jade must be examined with a lighted candle, and when it shows through as a red light bright as the newly risen sun, it may be known that there is jade. Sung (Su Sung, eleventh century) says: "In the present day neither in Lan-t'ien, Nan-yang, nor in Jih-nan is there any mention of jade, and it is found only in the Khotan (Yü-tien) country." During the After Chin dynasty in the reign

[1] The Tribute of Yü, which forms Part III of the Shu Ching, is the title of the First Book of the Hsia dynasty. It comprises the Division of the Empire of China, with the natural productions and revenue of the different districts as fixed by the great Yü, the founder of this ancient hereditary line. It is generally considered to be an authentic document of the third millennium B. C., and may be called a Domesday Book of China. The Commentaries quoted above are those written during the Han dynasty some two thousand years ago. (See The Chinese Classics, in 7 vols., translated by James Legge, D. D., late Professor of Chinese at Oxford University.)

of T'ien-fu (936–943), the superintendent of the banqueting-court, Chang Kuang-yi, was sent on a mission to Khotan, and wrote a diary of his journey, in which he states that "The place where jade is obtained in this country is called Jade River, which runs outside the walled city of Khotan. Its source is in the K'un Mountains, and it flows 1300 li from the west before it reaches the Bull's Head Mountain in Khotan, where it divides into three rivers. The first, called White Jade River, is 30 li to the east of the city; the second, called Green Jade River, 20 li to the west of the city; the third, called Black Jade River, being 7 li west of the Green Jade River.[1] Although the source is the same, the jade varies according to locality, and is of these three different colors. Every year in the fifth and sixth months a swollen torrent of water rushes down, and the jade follows with the current, its quantity depending on the size of the flood. The water recedes during the seventh and eighth months, and it can then be collected, the jade being fished for, as the natives say, according to fixed rules made by the state. For ritual vessels, ornaments, and food vessels they often use jade, and the jade which we have in the Central Kingdom (China) also comes from this country."

There are even fields where jade can be cultivated, according to the "Sou shên chi," which relates that "Yung-po, when his father and mother died, buried them in the Wu Chung Hills. There was no water on these hills, and Yung-po founded a station there for the distribution of tea. A certain man as soon as he had drunk brought out a pint of stone pebbles, gave them to him, and told him to plant them, and that they would grow into fine jade. It was afterward really so." In the present day even, in the province of Chih-li, within the boundaries of Yü-tien-hsien, there are fields where jade is cultivated.

Coming to the mountains which produce jade, these are not confined to one district. The Êrh Ya in its Geographical Section says: "The finest productions of the eastern country are the *hsün*, *yü*, and *ch'i* of the Yi-wu-lu Mountain"—Yi-wu-lu, according to the Commentary, being a mountain in the modern Liao-tung, *hsü*, *yü*, and *ch'i*, different kinds of jade. Again: "The finest productions of the western countries are the many jewels and jade of Ho Shan"—Ho Shan, according to the Commentary, being in the modern P'ing-yang at Yung-an-hsien. Again: "The finest productions of the Northwest are the *ch'iu*, *lin*, *lang*, and *kan* of K'un-lun Hsü"—*ch'iu* and *lin*, according to the Commentary, being the names of fine jades,—*lang*, *kan*, in shape like pearls; K'un-lun, the name of a mountain,—*Hsü* meaning its base.

Some other historical jades, like that found at Lan-tien of the Chou, at Ho-shih of the Ch'u State, at Chieh-lu of the Sung State, and at Ch'ui-chi of the Chin State, were all the highly prized treasures of the different states.[2] Jade was produced in other places, but none to rival these.

Besides these, there are the jade stones of Yárkand (Yeh'rh kiang), an account of which is extracted from the "Hsi Yü Wên-chien-lu": "Yárkand is a large walled city of the Mohammedan country. In its territory there is a river in which are found jade stones, the largest as big as round dishes or square peck-measures, the smallest the size of a fist or chestnut, some weighing as much as three or four hundred catties. There are many different colors, among which snow-white, kingfisher-feather green, bees-wax yellow, vermilion-red, and ink-black are all considered valuable; but the most difficult of all to get are pieces like mutton-fat with red spots, and others bright green as spinach with gold stars shining through, and these last two kinds are considered the rarest and most precious. Along the river-bed extends a deep layer of stones both large and small, the jade pebbles being mixed with the rest. When the time comes for collecting them an official takes up his station some distance from the bank, and a military officer is posted close to the river. Native Mohammedans who understand the work having been levied, they walk in rows of thirty or twenty, shoulder to shoulder, stretching across the river, with bare feet, over the stones. When they come to a jade stone the Mohammedan knows it by the touch of his foot, and stoops down to pick it up. The soldier on

[1] The account of the rivers of Khotan, as related here, is somewhat confused, and difficult to reconcile with more recent descriptions. The "Bull's Head Mountain" is described in the Annals of the T'ang dynasty as having two very steep-pointed peaks, with a Buddhist monastery containing a celebrated statue of Buddha built between them. It is there given the name Ku-shih-ling-ka, the Chinese transcription of the Sanskrit Gaushringa, which means also Bull's horns, and is stated to be situated 20 li southwest of the royal city of Khotan. The large river which now runs 50 li west of the modern city is known as Karakásh, or Black Jade River. The Yurangkásh, or White Jade River, which runs northward to join the other, passes 5 li east of the city. But both these rivers rise independently to the south of the K'un Lun Range, which they pierce at separate points.

[2] The period referred to here is that of the Chou dynasty. The sovereigns of the Chou, with their capital at Loyang, ruled over the Royal Domain or Central Kingdom, as suzerains of the surrounding feudal states, till their overthrow by the founder of the Ch'in dynasty in B.C. 255. The states mentioned above are the Ch'u, on the southwest, the modern Ssŭ-ch'uan; the Sung, on the east, ruled by the descendants of the Shang dynasty, which preceded the Chou; and the Chin, on the north.

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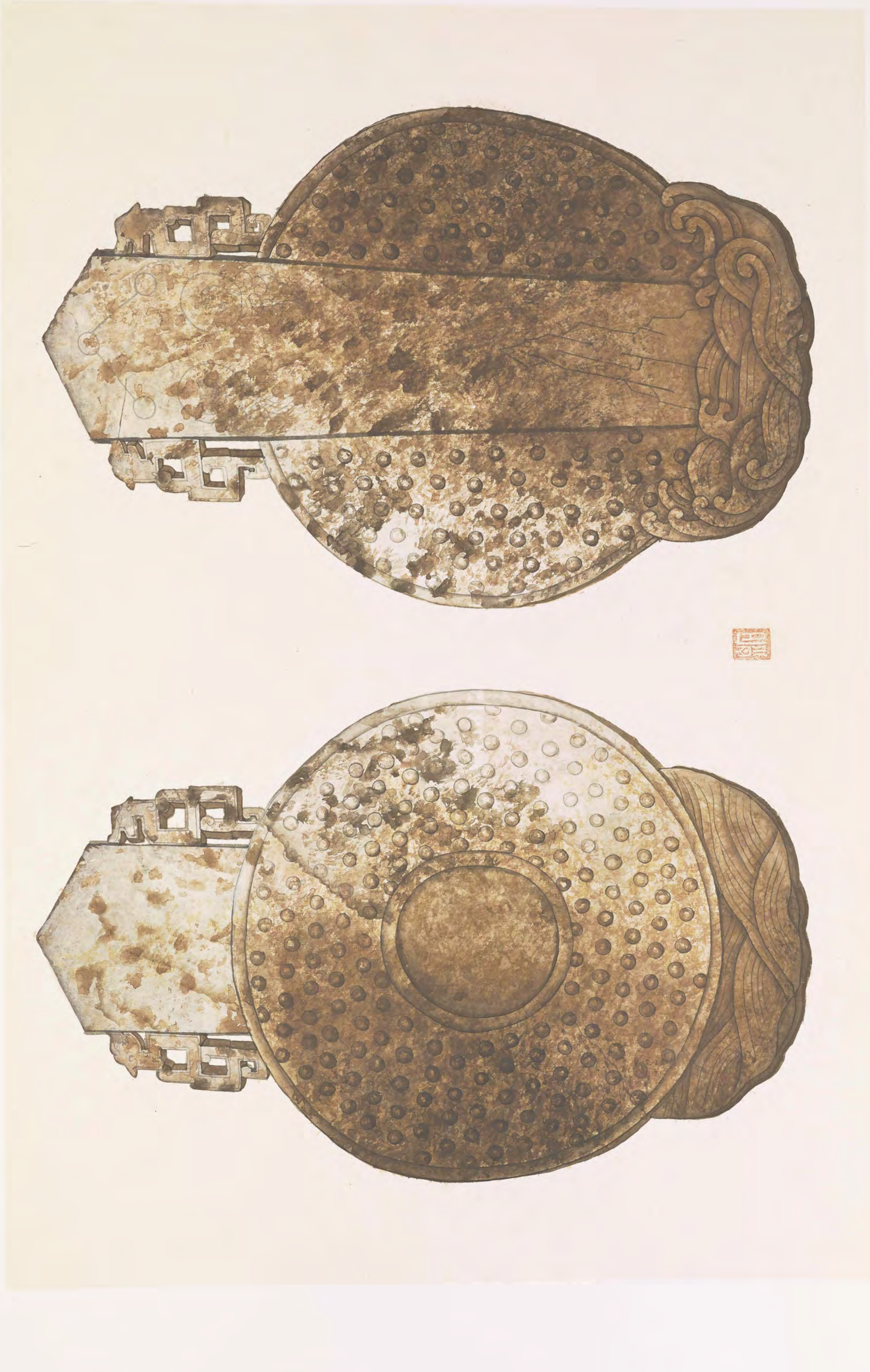
No. 318

SACRIFICIAL TABLET

(*Kuei Pi*)

Previous to Han Dynasty

Nephrite



the bank makes a stroke on his gong, the official then makes a red mark on his list, and when the natives come out of the water he requires of them as many pieces of jade as he has made marks."

"At a distance of 230 li from Yárkand there is a mountain called Mirtái Tapan,[1] where the whole side of the hill is of jade of all the different colors. But the stone is so mixed with jade, and the jade so veined with stone, that to get a quantity of blocks of pure jade, without flaws, weighing from 1000 to 10,000 catties, one must go to the top of the highest precipices, which are inaccessible to men alone. There are, however, yaks bred in this country which are trained to climb, and the Mohammedans, taking their tools with them, ride upon these yaks. They then scale the precipice, dig out the pieces with the chisel, and let them fall down to be collected afterward. These are commonly known as 'stone pieces,' also called 'hill stones.' Twice every year, in spring and autumn, Yárkand sends as tribute from between 7000 and 8000 up to 10,000 catties of jade."

"Still farther south, 700 li distant, is the Mohammedan walled city of Khotan (Ho-tien), situated in the midst of a fertile plain, 1000 li broad, the whole of which produces jade pebbles even in greater abundance than in Yárkand."

In the present day Hsi-an-fu, in the province of Shensi, Kuei-lin-fu in Kuangsi, Hsü-chou in Honan, as well as the districts of So-chü-hsien[2] and Ho-tien-hsien in the New Dominion, all these places produce jade.

There is a dark-green jade (*pi-yü*)[3] commonly called Yunnan jade, but there is no mention of the production of jade in this province; this kind of jade really comes from Burma (Mien-tien). The dealers in jade coming hither to and from China must all cross this province, and from this circumstance the name of Yunnan has been given to distinguish this peculiar kind of jade.

II. CRUDE JADE

By crude jade is meant unwrought jade. It has been collected, but not yet carved. From its own natural qualities and its peculiar solidity and pure color, with no addition of carved ornament, it is considered a thing of rare value.

The "Book of Annals" ("Shu"), in the Testamentary Charge (of King Ch'êng), says that the great jade, the *Yi* jade, the cærulean jade, and the river plan, were all spread out in the eastern chamber. The Commentary adds that the great jade came from Hua-Shan, the *Yi* jade from the northeast, and the cærulean jade as tribute from Yung-chou, its color being like that of the sky. These three must all have been of crude jade and uncarved, because there is no mention of utensils.

The "Fu jui t'ou" says: "Jade sprouts are rare and precious; not worked, but growing spontaneously, they shine like white flowers. In the reign of Wên-Ti of the Han dynasty, jade sprouts were seen in Wei-yang. It is said that these jade sprouts are seen when the five virtues are cultivated." According to the dictionary "Yun-hui," all jade grows, and while being formed there are sprouts, stem, flowers, and fruit, just as in growing plants. The jade sprout is, when it is first growing, like the first shoot of a plant; the stem, the finest kind of jade, like the best-grown centre of the plant; the jade flower, when full-grown, like the flower of the plant; and the jade fruit, when its formation is completed, as in vegetable fruit. All these jades can be used. According to the "Hsiang yü shu," jade six inches in diameter, which spontaneously emits light, is called *ch'êng*. The "Tao-tê-ching" says that jade must be broken up to make vessels.

Han Fei Tzŭ (third century B. C.) relates of Pien Ho, a native of the Ch'u State, that he found a piece of crude jade in the Ch'u Mountains and offered it to Prince Li. The prince sent a man to examine it, who declared it to be common stone, whereupon the prince, thinking it a fraud, cut off his right foot. After

[1] Tapan is the Chinese transcript of the Manchu Dabán, "mountain." The Mirtái Mountains are the same as the Belurtág, being the part of the great K'un Lun Range to the southwest of Yárkand.

[2] So-chü, anciently pronounced Sa-kü, is the old name of Yárkand; Ho-tien is a modern Chinese transcription of Khotan. These are two of the principal districts of Chinese Turkistan, or Hsin Chiang, the "New Dominion" as it is called also by the Chinese, since its conquest by the emperor Ch'ien-lung in the middle of the last century.

[3] *Pi-yü* is a general term applied to all kinds of dark-green jade varying in tint from sage- and olive-green, to the colors of moss and spinach, down to an almost black opacity. It may be either jadeite or nephrite. Most of the jadeite of this color comes from Burma, but the nephrite is really a production of the province of Yunnan. The boulder, No. 142, in the Collection, is a typical specimen of the dark-green Yunnan nephrite found in the vicinity of T'êng-yueh (Momien) and in the district south of Yung-chang-fu.

Prince Wu had succeeded, Pien Ho again presented it. It was again examined and reported to be stone, and they cut off his left foot. Prince Wên succeeded in his turn, and Pien Ho, holding the jade in his hand, lay at the foot of the Ch'u Mountains, weeping for three days and nights, till the tears were changed to blood. The prince sent his workers in jade to carve the rough stone, and got a priceless vessel. Thus it may be seen that the finest jade comes from this rough stone, and those who can distinguish the latter are real connoisseurs of jade.

This crude jade is also a substance of special efficacy as a medicine; it adds nervous energy and cures certain diseases. Hung-ching[1] says in the "Pên Ts'ao" that jade powder is prepared by pulverizing jade, and that it is not a distinct substance. The "Hsien Ching" says that when jade is prescribed it must be pounded to the size of rice-grains, and then suspended in bitter spirit to the consistence of mud. Some dilute it till like rice-water. When jade is ordered by the physician, carved vessels must not be used, nor unwrought jade that has been buried in graves. Kung says that when jade is taken it is best to reduce it to a liquid form. When roughly powdered to the size of small pulse, the essential part is dissolved in the intestines, the solid fragments passing away unchanged. It is also prescribed in fine powder in certain cases of constriction from stone and tumors, but the plan of pounding it to the size of small pulse is of most real value. In its pharmaceutical properties it is sweet, neutral, and not poisonous. It removes heat in the stomach, cures asthma and hot obstructions, and relieves thirst. When pounded to the size of small pulse and taken for a long time, it lightens the body and lengthens life, moistens the heart and lungs, helps the voice and throat, makes the hair glossy, and also aids to nourish the five abdominal organs. It is compatible with gold, silver, and the herb Mai-mên-tung, and is still more efficacious when boiled with these and given in combination. Other preparations of jade, like jade-water, jade-tea, and fine jade-tea, are all prepared from unwrought jade dissolved into fluid form in different ways. These various prescriptions are all contained in the Materia Medica books, in which the prescriptions are always taken from unworked jade. So highly is the best crude or rough jade valued. The same material when carved into vessels is not to be compared with it.

III. VALUE OF JADE

Jade is a substance hard and strong, yet of liquid aspect; it is fine-grained and beautifully marked, and yet brilliant. It is the choicest material found in the two kingdoms of nature, and quite unrivalled in value among the myriad substances.

The "Book of Poetry" ("Shih Ching"), in the Minor Odes of the Kingdom, says: "The stones of those hills can be used to polish jade." Ch'êng Tzŭ, in his Commentary, explains that though jade is of warm, moist aspect, and the finest production of the world, while stone is rough and coarse, and the worst of things, yet it is impossible to make vessels by rubbing together two pieces of jade, although when polished with stone jade may be worked and made into vessels. The "Rites of Chou" says that a cubic inch of jade weighs seven ounces (*liang*); a cubic inch of common stone, six ounces. In the "Book of Rites," Tzŭ Kung asked Confucius: "May I venture to ask why it is that the model man values jade and despises steatite? Is it because jade is rare and steatite common?" Confucius replied: "The model man of old compared jade to virtue. It is of warm, liquid, and moist aspect, like benevolence; it is solid, strong, and firm, like wisdom; pure, and not easily injured, like righteousness; when suspended, it hangs gracefully, like politeness; when struck, it gives out a pure, far-reaching sound, vibrating long but stopping abruptly, like music; though faulty, it does not hide its good points; when superior it does not conceal its defects, like loyalty; its brilliancy lights up things near it, like truth; it gives out a bright rainbow, like heaven; shows a pure spirit among the hills and streams, like earth; symbols of jade rank alone as gifts to introduce persons, like virtue; and in the whole world there is no one that does not value it, like reason. The Odes ('Shih Ching') say: 'When I think of my lord, He is soft-looking, like jade.' That is why the model man values it so highly."

According to the dictionary "Wu-yin-chi-yün," when placed in a strong fire and it does not become hot, it is true jade. According to the "Shuo-wên," the *p'an* and *yü* were precious jades of the Lu State. Confucius

[1] T'ao Hung-ching, who flourished A. D. 452–536, was one of the most celebrated adepts in the mysteries of Taoism.

says: "How beautiful are the *p'an* and *yü*, when looked at from afar so brilliant, when closely inspected so finely marked, excelling both in material and in brilliancy of surface." According to the "Pai Kuan," fire jade is red in color, and can heat a copper cauldron; warm jade will counteract cold, cold jade will remove heat; fragrant jade has a sweet smell; soft jade is of soft material; sun jade reflects a visible picture of the palaces of the sun: these being all precious things of rare occurrence. The "Life of Wang Mang" in the Annals of the Former Han dynasty says that fine jade will remove scars. The "Miscellanies" of the West Capital (of the Han) relates that there were in the Hsien-Yang Palace five lamps of green jade, seven and a half feet high, carved in the form of lizards, holding the lamps in their mouths, and that when the lamps were lighted their scales all moved and the bright light filled the hall. The "Tu-yang-tsa-pien" records that during the T'ang dynasty the kingdom of Japan presented to the emperor an engraved gobang board of warm jade, on which the game could be played in winter without getting cold, and that it was most highly prized. Also that the emperor Tai Tsung, of the T'ang, went one day to the Hsing Ch'ing Palace and found there in the double wall a precious casket containing a jade mace with the characters "soft jade mace" inscribed on the end. This had been offered in the period T'ien-pao (A. D. 742–755) by a foreign state. It could be bent until the two ends met, and straightened out again as rigid and firm as a stretched cord. Neither fire nor strokes of an axe hurt it. The sovereign, delighted with it as a magic thing, ordered an embroidered case of fine silk to be made for it, and a scabbard of green jade. Again, that 30,000 li east of Japan[1] is the island of Chi-mo, and upon this island the Ning-hsia Terrace, on which terrace is the gobang player's lake. This lake produces the chess-men which need no carving, and are naturally divided into black and white. They are warm in winter, cool in summer, and known as cool and warm jade. It also produces the catalpa-jade, in structure like the wood of the catalpa-tree, which is carved into chess-boards shining and brilliant as mirrors. Again, that in the reign Shun Tsung (A. D. 805) an embassy from the west presented two pieces of jade, one round, the other square, both half a foot in diameter, of brilliant surface reflecting like a mirror. Yi-ch'i Yuan-chieh, who was seated at the time before the emperor, after carefully examining them, said: "One is dragon jade, the other tiger jade. The round piece is the dragon, produced in water, and highly prized by the dragon, and if it be thrown into water it will emit rainbow colors. The square piece is the tiger, produced in precipitous mountain valleys, and highly prized by the tiger, and if it be rubbed with tiger fur, purple rays will proceed from it, and all animals will cower trembling." The emperor praised his words. The Additional Records of the T'ien-pao period say that Yang-Kuei-Fei kept jade in her mouth and sucked it to relieve lung thirst. In the "Yu-yang-tsa-tsu" it is related that the chamberlain Ma prized highly a bowl of pure jade, far excelling common jade, because even in the heat of the summer flies would not enter it, and because, when filled with water, the water was neither spoiled nor diminished even after a month, and also because the application of the contents of this bowl to inflamed eyes immediately cured them. The "Yi-chien-chih" says that in the reign of Hsüan Tsung (A. D. 847–859), of the T'ang dynasty, the emperor had twelve chess-men, on which were inscribed the cycle of the twelve hours, and that when a bowl was filled with water and these men put in, as the hour came round the proper one floated to the top without making an error of a moment.

But all these things, although deemed precious and of great rarity, are fit only to be regarded as toys and are of no real intrinsic value. It is different with the case recorded in the "Shih-chi" of the Ho-shih-pi of the Ch'u State, which was taken by Hui Wên Wang of the Chao, and for which Chao Wang of the Ch'in offered in exchange fifteen walled cities. The "Tso Chuan" says that when the Marquis of Wei was taken prisoner by the Chin State and sent to the capital, the king sent his physician Yen to poison the Marquis of Wei, but Ning Yu, an officer of the Wei, bribed the physician to dilute the poison so that he did not die, after which the Duke of Lu sent for his ransom a quantity of jade, including ten *chüo* to the king and ten *chüo* to the Marquis of Chin, whereupon the king consented and released the Marquis of Wei. The Commentary explains *chüo* to mean two pieces of jade. Again, when the Marquis of Chin attacked the Ch'i State and was about to cross the river, his officer, Hsien Tzŭ, tied together two *chüo* (pairs) of jade with red

[1] The book quoted here is by an author who is fond of the marvellous, and, as Mr. Wylie in his Notes on Chinese Literature (p. 155) says, many of his statements have the appearance of being apocryphal, so that we must not conclude from this passage that the Chinese at this time were in communication with America.

silk, and worshipped, throwing the jade into the water, after which they crossed over. These are instances of life and death to prince and state, and not to be compared with the fancy of a man fond of jade and thinking each piece of peculiar value.

We have also accounts of productions of human ingenuity seeking to rival the powers of nature, as in the "Han Wu Ku-shih," which relate how the emperor built a sacred temple and in the front hall erected trees of jade, with branches made of red coral, leaves of green jade, flowers and seeds blue and red made of precious stones hollowed out in the middle like little bells, tinkling as they hung.[1] Such things dazzle the eyes and please the fancy, but are of no other value.

Coming to the employment of jade as food, it is also valued by some for this purpose. The "Ho-t'ou-yü-pan" says that on the Shao-shih Mountains there is found a white jade-oil which, when eaten, confers immortality. The "Shih-chou Chi" says that at Ying-chou is found a jade-oil like spirit, which is called jade-wine, and which, when some cups of it are drunk, intoxicates and gives to men long life. Pao Fu-tzŭ says that the mountains which produce jade have springs of jade-oil, which flows out clear and brilliant as rock-crystal, and which, when stirred with any hollow stem, instantly turns to water; and that one cup of this when drunk will give a thousand years. Tsang Ch'i in the "Pên Ts'ao" says that the water which comes from jade, when drunk, will confer long life and a youthful aspect. That jade so eaten should confer immortality is a test of its high value such as could hardly be surpassed!

IV. OBJECTS MADE OF JADE

The "Book of Rites" ("Li Chi") says: "If jade be not carved the vessel cannot be made." Mencius says: "Now you have a piece of rough jade, and even if of the value of ten thousand pieces of silver, yet you will entrust it to the jade men to be carved." Therefore the employment of jade to make vessels is not a work of modern times. The Annals ("Shu Ching") tell us that he (Shun) established the sphere and the jade transverse to regulate the seven planets. Again, in the Metal-bound Coffer that the Duke of Chou stood erect, having placed the *pi* (on the altar) and holding the *kuei* in his hand. Again, in the Testamentary Charge that after his (King Ch'êng's) attendants had put on his crown and robes, he leaned on the jade table.

The "Book of Poetry" ("Shih Ching") in the State Odes says: "She grows old with her lord, wearing six jade pins in her hair"; the Commentary explaining it to mean six pins ornamented with jade. Again, "He presented to me a quince, I returned a *chü* of fine jade. He presented to me a peach, I returned a *yao* of fine jade. He presented to me a plum, I returned a *ch'iu* of fine jade." The Commentary explains that these things were all of the finest jade, the *chü* being girdle appendages, the *yao* and *ch'iu* worn also as ornaments. Again, "With woollen robes like red jade," *mên*, according to the Commentary, being the red color of jade. Again, "When I know that you are coming, I will present you with all the jade ornaments," meaning, says the Commentary, the jade set worn on the left and right sides. Again, in the Lesser Odes,[2] "They (boys) will have jade sceptres to play with."

In the "Rites of Chou" ("Chou Li"), the First Minister, when there is a great court reception of the nobles, aids the sovereign with the jade presents, the jade offerings, the jade tables, and the jade libation-vessels. Again, the Chief of the Jade Treasury, when the nobles are summoned for a sworn convention, prepares the jewelled vessel and the jade dish (for blood). Again, the Minister of Rites, when there is a great sacrificial worship, laves the jade wine-vessels and hands the jade dishes; the Commentary explaining *ch'ang* as vessels for wine, and *tzŭ* as dishes for holding millet. Again, under the Minister of Punishment, the lesser envoy regulates the six symbols (*ju-i*) of rank: the symbol of domination (*chên kuei*) peculiar to the emperor, the pillar symbol (*kuan kuei*) held by princes of the first rank, the symbol of sincerity (*shên kuei*)

[1] A pair of little trees of this kind is often presented as part of the trousseau of a rich Chinese bride of the present day, standing in flower-pots of jade, cloisonné enamel, or rare porcelain, filled with coarsely powdered lapis lazuli, or coral, instead of earth. Covered with glass shades, they make a brave show in the procession of wedding-gifts which is always carried through the streets of a Chinese city.

[2] The Lesser Odes form a section of the Shih Ching. Our author is too concise, but he expects his reader to have the Book of Poetry on the tip of his tongue, so that one line is suggestive enough. This one is part of two verses often quoted to contrast the lot of boys and girls in China. Speaking of King Hsüan, they run, according to Dr. Legge's translation: "Sons shall be born to him; They will be put to sleep on couches. They will be clothed in silk robes. They will have jade sceptres to play with." "Daughters shall be born to him; They will be put to sleep on the ground; They will be clothed in wrappers; They will have earthen tiles to play with."

48

No. 332

GIRDLE-ORNAMENT

(*P'ei*)

Han Dynasty (B. C. 206–A. D. 220)

Nephrite

No. 335

HORN-SHAPED CUP

(*Chüeh Pei*)

T'ang Dynasty (618–906)

Nephrite

No. 323

DECORATED CELT

(*Yao Chan*)

Previous to Han Dynasty

Nephrite

No. 316

PART OF CHARIOT-WHEEL NAVE

(*Kang-t'ou*)

Previous to Han Dynasty

Nephrite

Nos. 333, 334

TWO SQUARE SEALS

(*Fang Yin*)

Han Dynasty (B. C. 206–A. D. 220)

Nephrite


角杯
玉牌
玉
車輅輞
玉印

by princes of the second rank, and the symbol (*kung kuei*) by princes of the third rank, the grain symbol (*ku pi*) by princes of the fourth rank, and the reed symbol (*p'u pi*) by princes of the fifth rank. He arranges the six precious offerings (*pi*): horses with the *kuei* symbols, furs with the *chang*, plain silks with the *pi*, brocaded silks with the *tsung*, silks embroidered in colors with the *hu*, and silks embroidered in black and white with the *huang*. These six offerings were used as presents for the cultivation of good relations with the feudatory princes.

In the "Book of Rites" ("Li Chi"), in the royal ceremonial hall, jade cups and large vessels were used for wine, jade tazzas and carved bamboo dishes for the food, and jade cups for libation. This book mentions also the four *lien* and the six *hu* of the sovereigns of the Hsia dynasty, described in the Commentary as jade vessels for holding millet and grain in the Ancestral Temples.

The "Tso Chuan," in the seventeenth year (B.C. 524) of Duke Chou, records a speech of the P'i Tsao of Chêng: "If we use wine-vessels of jade and jade libation-cups, Chêng will escape the fire." Again, in the twenty-ninth year of Duke Chao (B.C. 512), the duke presented to Kung Yen a robe of lambskin, and sent him to offer a *lung fu* to the Marquis of Ch'i. He also offered the lambskin robe, at which the marquis was pleased, and gave him Yang-ku. The Commentary says that *lung fu* was the name of a piece of jade; Yang-ku, a walled city of the Ch'i. The "Êrh Ya," an ancient dictionary, in its section on apparatus, says that the horn bows of the time, ornamented at both ends with jade, were called *kuei*. Again, that *kuei* one foot and two tenths long were called *chieh; chang* eight tenths of a foot long were called *shu;* and *pi* six tenths of a foot across were called *hsüan*. When the body (in circular pieces) was twice as large as the central hole, it was called *pi;* when the hole was twice as large as the body, *yuan;* and when the hole and body were alike, *huan*.

The "Miscellanies" of the Western Capital of the Han dynasty ("Hsi-ching-tsa-chi") say that in the Ch'in country, at Hsien-yang, they had a jade flute over two feet long pierced with twenty-six holes. When the emperor Kao Tsu first went to Hsien-yang, and went round the treasuries there, he saw this, and played on it, whereupon mountains and groves with horses and chariots continued to appear in a mist, vanishing altogether when he ceased playing. He gave it the name of the "tube of beautiful visions."

In the "Han Annals" ("Han Shih"), in the life of Wên Ti, the emperor, in the ninth month of his sixteenth year (B.C. 164), is recorded to have acquired a jade cup on which were engraved four characters signifying "Long life to the sovereign of men!" Again, in the life of Wu Ti, the emperor built the Têng-kuang Tower, and from the top of the tower resounded the bell made of bright-green jade.[1] Again, that the emperor, when his work was finished and rule established, announced the completion to heaven, and engraved a record on stone tablets, with headings of jade painted with gold characters. Again, that the Wei-yang Palace had gates of jade.

In the "San-fu-huang-t'ou," Tung Yen is described as lying in Yang-ch'ing Hall on a couch made of variegated stone, with dishes before him of purple jade carved with coiling dragons, all inlaid with different kinds of precious stones; and he is also said to have had a round dish made of jade crystal filled with ice standing before him. The jade crystal and the ice were so exactly alike that an attendant one day, exclaiming that the ice, having no dish, would melt and wet the mat, threw it away, letting the dish drop, so that both ice and dish were shattered together. This jade crystal had been sent as tribute from the Khotan State, and the emperor Wu Ti had given it to Tung Yen.

In the Annals of the Wei dynasty the emperor Wên Ti is said to have had a sword, the head mounted with a brilliant pearl, the hilt inlaid with blue jade, which he often handed to his attendants to destroy goblins.

In the Biography of Hu Tsung we read that during the Wu dynasty, when digging the ground, there was found a bronze casket, with the cover made of glass, and a second lid of mother-of-pearl, which was opened, and a white jade sceptre (*ju-i*) found inside. The sovereign questioned Tsung, who replied that Ch'in Shih-huang, on account of the existence of the spirit of the Son of Heaven in Chin-ling (Nanking), had buried precious things there in several places to keep down the sovereign spirit.

[1] A jade hand-bell with tinkling tongue of jade is sometimes used to accompany the Buddhist priest when intoning his Sanskrit prayer. The handle is carved in the form of Buddha and the outside of the bell ornamented with Buddhist scenes and figures. The Tibetans and Mongols value these bells very highly. I tried to purchase a beautifully carved one for the Bishop Collection at the New Year's Fair at Peking in 1889, but a Mongol prince outbid me by an offer of twenty horses out of the drove he had brought down from his own country.—S. W. B.

The "Yi Yuan" says that, under the Chin dynasty, Wang T'êng, when he was governor of Yeh, was travelling to the Ch'ang Shan, when there was a great fall of snow, covering the ground to a depth of several feet. Before the door of his tent, over a square space some ten feet broad, the snow all melted as it fell, whereupon he dug there, and found a jade horse more than a foot high. Also, that Yang Tzŭ-yang, when at Hung-nung, hearing a sound proceeding from the ground, dug there, and discovered a jade pig over a foot long. In the records of Liang-chou it is written that, in the second year of Hsien-ning (A. D. 276), a robber plundered the grave of Chang Chün, and found there a wine-vessel of white jade, a jade musical pipe, and a jade flute. The "Shih-yi Chi" says that, in the first year of Tai Shih (A. D. 265) of the Chin dynasty, natives of the Pin-ssŭ country came to court with clothes made of jade of different colors, like the armor of the time. Also, that the country of Po-te sent to the emperor a ring made of black jade, like lac in color. Again, that Wang Yen, during the Chin, made the handle of his fly-brush (*chowry*) of jade. Again, that the Yin Ch'in State, situated to the north of Turkistan (Hsi-yü), sent to the emperor, in the reign of Wu Ti of the Chin, a thousand strings of jade money, carved into rings, each ring weighing ten ounces (*liang*), with four characters engraved on it meaning "Celestial longevity, everlasting prosperity!"

The "Southern History" ("Nan Shih") records that, during the Liang dynasty, in the sixth year of T'ien-chien (A. D. 507), the Khotan State sent envoys with offerings of the productions of their country, and that in the seventh year of Ta T'ung (A. D. 533) they again offered a jade Buddha carved in their country. According to the "Rules of the Six Boards" in the T'ang dynasty, in the worship of the gods of heaven and earth they used musical plaques of stone in the ancestral temple, and in the imperial palace they used musical plaques of jade. The "T'ang History" records that the emperor Kao-Tsung, in the first year of the period Ch'ien-fêng (A. D. 666), when he worshipped T'ai Shan, had writings made on tablets carved out of jade, with gold characters incised, which were enclosed in a jade casket. The "Tu-yang-tsa-pien" says that T'ang Yuan-tsai had a fly-brush (*chowry*) made of red dragon's beard, with a ring carved out of red jade on the handle.

The "Sung History" ("Sung Shih") records that, in the third year of the T'ien-sheng period (A. D. 1025), the Khotan (Yü-tien) State sent envoys to the imperial court with tribute of a jade saddle and harness and a girdle of white jade. The "Hsü Wên Hsien T'ung K'ao" says that during the Yuan dynasty the commander-in-chief Po-yen,[1] when he went to the Khotan country, while digging a well discovered a jade Buddha between three and four feet high, of the color of freshly cut lard, which showed in a bright light all the sinews, bones, and blood-vessels, which he immediately sent to the emperor. There was also a block of white jade there six feet high, five feet broad, and seventeen paces long, but this could not be transported on account of its weight. The "Chin History" ("Chin Shih") records that, in the twenty-sixth year of the Ta-ting period (A. D. 1186), a great-grandson was born to the emperor, and that there was a banquet in the Ch'ing-ho Palace, at which the emperor gave him a set of mountains carved in jade with hares and tassels, while Chang Tsung (the heir apparent) offered to the emperor a paper-weight of jade carved in the likeness of two camels, a jade instrument for playing the guitar, a phenix hair-pin, and floral ornaments of jade.

As we come down to the present day we find larger things carved out of jade, like flower-vases, dishes, large bowls, and cauldrons, as well as smaller objects, like girdle-ornaments, hair-pins, and rings. For the banquet-table we have bowls, cups, and wine-vessels of varied form; for congratulatory gifts, round money and oblong talismans. There are beakers and vases to be frequently replenished at wine-parties, wine-pots, and the three cups used at the wedding ceremony. There is the Buddha of longevity to pray to for life long as the southern hills, and the screen carved with the eight Taoist immortals. There are *ju-i* sceptres and mirror-stands as valuable betrothal presents; hair-pins, ear-rings, ornaments for the forehead, and bracelets as prized jewelry for personal adornment. For the scholar's study there are the set of vessels for burning the incense of a hundred ingredients, the tripod, vase, and box; for more luxurious halls are flowers in pots, each pair filled with flowers appropriate to the season. There are combs of jade for dressing the hair and arranging the black tresses in the early morning; pillows of jade for laying across the couch to snatch a dream of elegance at noon. There are rests for the wrist when the ink-pallet is being used; weights for

[1] Po-yen is the Chinese form of the Mongolian Bayan, the celebrated military commander who conquered China for Kublai Khan. He died in the year 1294.

the tongue of the dead arranged for the funeral. There are rouge-pots and powder-boxes to give to the face of beauty the bloom of the peach; brush-receptacles and ink-rests to hold the weapons of the scholar before his window. There are the eight precious emblems of good fortune for Buddhist temples: the wheel of the law, conch-shell, umbrella, canopy, lotus-flower, jar, pair of fish, and the endless knot; there are pomegranates bursting open, sacred peaches, and Buddha's-hand citrons — emblems of the all-prayed-for three abundances.[1] There are jade chains of round links, tokens of lasting friendship; jade seals for guaranteeing the authenticity of documents. There are beads for the rosary, to count the number of invocations of Buddha; paper-weights for the table of the scholar's study; tassel-ornaments for the fan-screen to shield the face of the coquette; jade keyless locks for fastening around the necks of children. Jade is used to carve a bracelet for the arm of the infant to give it something to suck; jade is also used to be interred with the body of the dead in the hope of preserving it from decay. Among other things are mortars and pestles for pounding drugs, and thumb-rings for protecting the hand of the archer. Lovers of tobacco-smoke prefer a mouthpiece of jade for their pipes, and gourmands like to use jade chop-sticks. Jade rings are worn on the finger, to save from shipwreck in the pursuit of wine and pleasure; jade pipes are used for inhaling clouds of smoke by those addicted to the opium of the West. In short, from the Son of Heaven down to the commoner, in adult, marriage, funeral, and ancestral ceremonies, for daily wear or when food is served, there is no one who does not on many occasions make use of jade.

V. JADE USED BY THE SON OF HEAVEN

The scholars of ancient times compared jade to virtue, because dirt could not soil it nor friction injure it. It is moist-looking, yet translucid; of warm aspect, yet hard. Hence, from the three ancient dynasties to the present day all the principal sacrificial vessels of the ancestral temple, as well as the most valuable objects in the imperial palace, have generally been fashioned of fine jade, so that it is necessary here to describe its use by the Son of Heaven.

The "Book of Poetry" ("Shih Ching"), in the Odes of Wei, says: "With his ear-ornaments of beautiful jade." The commentator says that these ear-ornaments when made of jade were called *tien*, and that those worn by the Son of Heaven were made of jade. Again, in the Minor Odes of the Kingdom: "His scabbard studded above and below with gems." The Commentary says that *pi* was the scabbard, which was studded above with *p'êng*, below with *pi*, when worn by the Son of Heaven with his coat of mail; and that the *p'êng* was made of jade, and the *pi* of mother-of-pearl. Again, in the Greater Odes of the Kingdom: "On his right and left they held the libation-cups." The Commentary explains that the half-*kuei* was called *chang*, and says that during sacrificial worship the king poured the wine from a *kuei*-handled cup, the nobles in attendance offering a second libation from *chang*-handled cups, which were held by them on the right and left. And again, "He received the large and small sceptres (*ch'in*)." The commentator Chêng explains that the small sceptre was the *chên kuei*, which was one foot and two tenths long; the large sceptre, the large *kuei*, three feet long; and that both belonged exclusively to the emperor.

The "Book of History" ("Shu Ching"), in the "Ta Ch'uan," says that Yao, when he resigned the empire to Shun, gave to him the T'iao-hua jade. Again, in the "Canon of Shun," that he called in the five jade symbols of rank, and on the same day of the next month gave audience to the Chief of the Four Mountains and all the pastors, returning the symbols to the several princes. The Commentary explains these five symbols, *jui*, to be the jade symbols of the five grades of princes, the *kung*, *hou*, *po*, *tzŭ*, and *nan*, being the jade sceptres appertaining to each grade.

According to the Rites of the Chou dynasty ("Chou Li"), the Son of Heaven kept the *mao*, which was four inches long, for the reception of the several princes. The commentator Chêng says that this *mao* was of jade, and that the jade was called *mao* to signify that the Son of Heaven enveloped the world with his virtue

[1] An abundance of sons, of years, and of happiness. The ripe fruit of the pomegranate, cracked open so as to expose the seeds inside, is an emblem of an abundant progeny; the miraculous peach is the fruit of the god of longevity; the Buddha's-hand citron, the attribute of the god of happiness.

as with a canopy. When the nobles first received investment the emperor bestowed on them the *kuei* tablets. The angles and tops of these *kuei*, and the carved under surface of the *mao*, were made of corresponding size, length, and breadth, so that when the princes came to court, the Son of Heaven placed the carved surface on the top of the tablet, and if it did not fit it was proved not to be genuine. Therefore these symbols of rank were called *jui*. Again, it describes the Decorator of Chariots as taking charge of the five chariots of the king, of which the first was called the jade chariot. Again, it says that the king held the great tablet, and kept the tablet of domination; the Commentary explaining that the great tablet, three feet long, was held by the Son of Heaven, and that the tablet of domination, one foot and two tenths long, was the one that used to be sent with the betrothal presents of the Son of Heaven.

The "K'ai Shan T'ou" says that when Yü Wang received the command to remove the inundating waters, Yuan-yi Tsang-shui gave up to him the black tablet of jade, on which were inscribed characters from which he knew the high and low places of the nine provinces, and was enabled to dig channels and lead off the waters; and that when his work was finished he buried the black tablet on a celebrated mountain, the two characters being in an antique script, mysterious and most ancient, and quite unintelligible to ordinary scholars.

The "Classic of Rites" ("Li Chi") says that the Son of Heaven wore in his girdle white jade with tassels of black silk. Again, in the section Yü Tsao, that the hat worn by the Son of Heaven had twelve rows of jade. Again, it says that the Son of Heaven held the sceptre (*t'ing*) straight and upright in the face of the world, the Commentary adding that this sceptre was called the great tablet (*kuei*); also, that the tablet (*hu*) of the Son of Heaven was of fine jade. Again, it says that when the sovereign summoned the officers, he used three *chieh* as tokens—two tokens to come hurriedly, one token at ordinary speed; if at the office, they must not tarry to change shoes; if outside, they must not wait for a chariot. The commentator Chêng says that these tokens were made of jade, and that they were warrants to authenticate the commands of the sovereign. When the sovereign sent messengers to summon the high officers, he used sometimes two tokens, sometimes one (hence the general name of the three *chieh*), the number used being according to whether the occasion was ordinary or urgent: if urgent, two tokens to come quickly; if not urgent, one token to come at ordinary speed. The "Illustrations of the Three Rituals" ("San Li T'ou") says that the Son of Heaven had six tables, the jade table being the first. Also, that the red shield and the jade axe were the weapons wielded by the Son of Heaven in temple-worship. The "Lu-p'u-chi" informs us that when the Son of Heaven went to the audience-hall, and the hundred officers were collected, at three strokes of the jade mace they marshalled their ranks. The Life of King Mu (of the Chou dynasty) refers to the *hsüan-chu* among the valuables of the Son of Heaven, which the commentator explains to be a kind of jade.

A "Memoir of the State Seals" says that when Ch'in Shih-huang had united the Six States he gained possession of the jade of Pien Ho, and ordered the workmen to fashion it into a state seal, four inches square, with a handle carved in the form of a lizard, and commanded Li Ssŭ to write in the insect and fish script eight characters meaning "According to Heaven's decree may rule be everlasting!" which were engraved by the skilled workman Sun Shou, and it was called the seal of succession to the empire. Tzŭ Ying brought this seal as an offering to Kao Tsu, the founder of the Han dynasty. Wang Mang, when he usurped the throne of Han, tried to compel the empress to give up the seal, when it fell to the ground, slightly injuring one of the horns of the lizard. Subsequently this seal came into the possession of the emperor Kuang Wu. After the rebellion of Tung Cho, Sun Chien found it when digging a well, and sent it back to Hsien Ti, who soon after resigned it to the Wei. The Wei resigned it to the Chin, from whom it passed to the Sui. After the assassination of Yang Ti, the empress Hsiao fled with it to the north, till in the fourth year of Chên-kuan (A. D. 630) the empress Hsiao sent the seal as an offering to the T'ang. When Fei Ti (the last emperor of the After T'ang, A. D. 935) burned himself it is not known what became of the seal. The "Old Rules" of the Han dynasty says that there were in the Han Palace six state seals, all made of white jade, with handles in the form of horned lizards, the inscriptions on which were: "The despatch-seal of the Emperor"; "The seal of the Emperor"; "The true seal of the Emperor"; "The despatch-seal of the Son of Heaven"; "The seal of the Son of Heaven"; and "The true seal of the Son of Heaven." Of these six seals the first was used on imperial despatches sent to the nobles and princes, the third to

5-2

No. 623

ARTIST'S BRUSH-HOLDER

(*Pi T'ung*)

Ch'ien-lung (1736–95)

Nephrite


敬芝軒第二畫

summon the high officers for a military expedition, the fourth on despatches sent to foreign countries, as well as in the worship of heaven, earth, and the gods.

The "Book on Official Robes" (of the Han Annals) says that, according to the rules of the Han, the Son of Heaven wore a seven-lobed hat of jade. The "Book on Imperial Equipage" says that the seal of Lan-tien jade of the Ch'in dynasty, with lizard handle, was not included among the six seals. It was worn by the emperor Kao Tsu, and was known afterward as the seal of succession to the empire. Again, that the emperor Kao Tsu, when he ascended the throne and offered worship to heaven, used jade tablets, of brilliant white color, flecked with spots and with moss-like markings of red, green, and brown, and with black tints shining brightly through three leaves in number, inscribed with a hundred and seventy characters, in the official script of the Han, written in clear and strong style. The Han Annals, in the Memoir of Kao Ti, record that the sovereign had wine set out in the front hall of the Wei-yang Palace, and offered a jade cup filled with it to his imperial father, wishing him long life. Again, that the emperor Kao Tsu sent Chang Liang with a present of a square vessel of jade to Fan Tsêng.

The Imperial Annals of the T'ang record that the founder of that dynasty was the first to fix rules for girdles, and from the Son of Heaven down to the hereditary nobles and princes, the three chief ministers, the presidents of the boards, generals and officers of the first and second grade,—all these were allowed to wear girdles of jade, that of the Son of Heaven being set with twenty-four plaques. The "Chronicles" of the reign of Ming Huang relate that the empress, having sent one day for the imperial grandsons, and seated herself in the palace to look at their games of play, had the jade rings, bracelets, wine-cups, and dishes, that had been sent as tribute from western countries, brought out and arranged so that each one might take whatever he pleased, when they all crowded up and took as many as they could, the sovereign alone sitting still quite impassive. The empress marvelled greatly and stroked him on the back, exclaiming, "This child will grow up to become a most peaceful emperor," and ordered a jade dragon to be brought, which she gave to him. This jade dragon was several inches long, and had been originally found by the emperor Tai Tsung in the Chin-yang Palace, and the empress Wên Tê used to keep it in her box with her robes, and now that it was given to the emperor, he valued it most highly. It was afterward placed in the treasury, and although only a few inches in size, its warm liquid body and cunning workmanship made it absolutely unique. Whenever no rain fell in the capital it was reverentially brought out and prayers were offered; and if an abundant rain was about to fall, the horns appeared on close inspection to be raised. A Record of the reign of K'ai-yuan relates that whenever under the T'ang dynasty an imperial child was born in the palace, the emperor sent jade money with the sliced fruit as "baby-washing gifts"[1] of good augury, the money being inscribed with prayers for prosperity. The Miscellanies of Tu-yang relate that the emperor Su Tsung bestowed on Li Fu-kuo two unicorns carved in fragrant jade, which could be smelled several hundred paces off, and that Fu-kuo used to keep them beside his seat.

The Regulations of the Imperial (Sung) Dynasty say that when the dynasty was reëstablished there were kept in the imperial treasury eleven jade seals. The first, called the "State-protecting sacred seal," was inscribed, "Endowed by Heaven with prosperity for myriads and tens of myriads of years everlasting." The second, called the "seal of appointment," was inscribed, "Having received the appointment from Heaven for everlasting time." These two seals were used in the worship of the mountain T'ai Shan. The third, called the "seal of the Son of Heaven," was used in replies to foreign countries. The fourth, called the "true seal of the Son of Heaven," was used for the levy of a great army. The fifth, called the "despatch-seal of the Son of Heaven," was used to seal the appointments of nobles, etc. The sixth, called the "seal of the Emperor," was used in replies to border kingdoms. The seventh, called the "true seal of the Emperor," was used on despatches accompanying presents to border kingdoms. The eighth, called the "despatch-seal of the Emperor," was used to seal imperial autographs. The above were what were called the eight state seals. The ninth, called the "seal of appointment," had an inscription written by the founder of the dynasty, reading: "The seal of appointment of the Great Sung." The tenth, called the "seal of established rule," had an

[1] It is the custom in China to wash the child for the first time on the third day after its birth, the functions being performed with certain religious ceremonies and oblations of fruit and wine. Charms of ancient *cash*, silver talismans, or such-like gifts of good omen are provided, one of which is bound round the wrist of the child by a red string and kept on till the wearer is fourteen days old.

inscription written by the emperor Hui Tsung, reading: "Rule encompassing heaven and earth, and aiding the spirits in dark places; power equal to the great Creator for a myriad ages everlasting." The eleventh, called the "seal of reëstablished appointment," was inscribed the "seal of appointment of the reëstablished Great Sung." Including the above, there were in all eleven seals.

Under the reigning Manchu dynasty the court girdle worn by the emperor is of yellow color, with four square plaques of gold engraved with dragons. The ornaments are of lapis lazuli for the services at the Temple of Heaven, of yellow jade for the Altar of Earth, of red coral for the Altar of the Sun, of white jade for the Altar of the Moon. The jade palanquin and jade chariot (in which the emperor rides) are both made of wood lacquered red, each one decorated with four round panels of jade. The state seals are kept in the Chiao-t'ai Palace, and there are twenty-three jade seals, inscribed: "The seal of appointment of the Great Ch'ing dynasty," "The seal of the Son of Heaven," "The seal of honor for kindred of the Emperor," "The seal of love for kindred of the Emperor," "The true seal of the Emperor," "The seal of reverence to heaven and zeal for the people": all made of white jade; "The seal of the Emperor for the worship of heaven," "The despatch-seal of the Emperor," "The despatch-seal of the Son of Heaven," "The seal of Imperial order," "The seal of gracious instruction," "The seal of promulgation of the classics and history": all made of dark-green jade; "The seal of the Emperor," "The true seal of the Son of Heaven," "The seal of Imperial patent," "The seal of reward of valor," "The seal of control of Empire," "The seal of punishment of crime and quiet of the people," "The seal of Imperial regulation of the myriad regions," "The seal of Imperial regulation of the myriad people": all of clear-green jade; "The seal of Imperial autographs," "The seal of Command of the Six Armies," and "The seal of wide region": all made of black jade. Besides these, there are the state seals reverentially kept at Shêng-king (the capital of Manchuria), including the six jade seals inscribed: "The seal of appointment of the Great Ch'ing (dynasty)," "The seal of the Emperor," "The seal of reverence of heaven, respect of ancestors, affection for scholars, love of the people": all three made of dark-green jade; "The seal of the Emperor," "The vermilion seal of examination of the four quarters," and "The seal of Imperial command": all made of clear-green jade.

Again, when sacrificial titles are conferred in honor of deceased emperors and empresses, jade seals and jade tablets are always used, and reverentially placed in the Ancestral Temple. These are all carefully made in the imperial household, and presented in the first place to be inspected by the emperor.

The above are some clear examples of the use of jade by emperors of successive dynasties.

VI. JADE USED BY THE STATE

The use of jade by the Son of Heaven has been shown to be most constant, and in like manner it has always been as highly esteemed by the state, as may be proved by consulting the records still extant and searching the official writers. In the "Book of Annals," in the second, entitled "Hounds of Lü," the precious jades were distributed among the uncles of the king ruling over states. In the "Rites of Chou," the Superintendent of the Magazine of Jade looked after the gold and jade of the king, made ready the jade worn by the king on his robes, girdle, and as jewels, prepared the jade eaten by the king when fasting,[1] and furnished the jade placed in the mouth of the royal corpse. Also, the second minister superintended the officer in charge of the tablets, who distributed them to the states and explained their use to help the commands of the king, the rulers of the states using tablets of jade. Again, under the third minister (of Rites) the Grand Director of Sacrifices made of jade the six objects used in worshipping heaven and earth and the four quarters, the dark-green round tablet (*pi*) to worship heaven, the yellow octagonal tablet (*tsung*) to worship earth, the green pointed tablet (*kuei*) to worship the east, the red tablet (*chang*, in the form of a half-*kuei*) to worship the south, the white tiger tablet (*hu*) to worship the west, and the black semicircular tablet (*huang*) to worship the north. The Commentary, quoting the "Êrh Ya," says that the *pi* had the body twice as broad as the central hole, that the *tsung* had eight sides like the earth, and that the *kuei* had the top corners

[1] The emperor fasts before important religious ceremonies, such as in the annual sacrifice to heaven, spending the night in the Hall for Fasting, one of the temple buildings, and during his fast the only thing permitted to pass his lips is a kind of *purée* made of finely powdered jade stirred up in hot water.

on the right and left truncated half an inch, that the *chang* was the *kuei* halved, that the *hu* was fashioned like a tiger to symbolize the fierceness of autumn, and that the *huang* was the *pi* cut in halves. Again, the President of the Celestial Magazine (T'ien-fu) kept the royal jade tablets and the great sacrificial vessels of the state, and when there was a grand sacrificial ceremony or a royal funeral he brought them out and arranged them, and put them by again when the service was finished. The Commentary says that these things included the jade tablets of rank as well as the most beautiful vessels of jade, which were set out during the sacrifices to heaven and to the royal ancestors, as well as the grand funerals, to attest the splendor of the state.

So the "Book of Annals," in the Testamentary Charge of King Ch'êng, records that they set out the precious things, the red knife, the great lessons, the large *pi*, and the jade tablets of rank, all in the western chamber, the Commentary explaining the *pi* to be large round symbols of jade, and the two kinds of tablets both as a foot and one fifth long. Again (in the Ritual of the Chou), the T'ien-fu says that the president, in the last month of the winter, arranged the jade to determine whether the coming year would be good or bad. The commentator explains that the jade arranged was the jade for sacrifice to the gods. Again, the Conservator of Tablets (Tien jui) has charge of the preservation of the jade tablets of rank and the jade vessels. He distinguishes the names, the things, and the ceremonies in which they are used, and furnishes the proper appendages to be worn. The Commentary says that the tablets held in the hand were called *jui*, which included the royal tablet as well as the rest, and that the jade used in the sacrifice to the gods, called here vessels, included the fourfold *kuei*, etc. The appendages included the mounting, the silk cords and tassels bearing the same relation to the jade as robes to men. Again, that the *chuan*, *kuei*, *chang*, *pi*, and *tsung* were each suspended by a single loop of two colors and worn by officers at the royal receptions. The fourfold *kuei*, with round body, was used in sacrifice to heaven and in the worship of the Supreme Ruler. The Commentary says that this was fashioned round in the centre, a large tablet being taken and carved in the middle in the form of a round *pi*, with the body twice as broad as the hole in the middle, and on each of the four sides a *kuei* carved projecting from each, the central body being also called *ti*. Also: The twofold *kuei*, with central body, used in sacrifices to earth and in the worship of the four quarters. The libation *kuei*, with ladle (*tsan*), for sacrificing to the ancient kings and for the entertainment of guests: explained in the Commentary to be a tablet carved at the top into a vessel, from which the wine could be poured out in sacrificial worship, and called ladle (*tsan*). Again: The round tablet, with one projection (*kuei pi*), was used in sacrificing to the sun, the moon, the planets, and the fixed stars. The half-tablet, with point projecting (*chang ti shih*), was used in sacrificing to the mountains and rivers and in ceremonial banqueting of guests. The measuring tablet (*t'u kuei*), to measure the shadows of the sun and moon in the four seasons. The precious tablet (*chên kuei*), to summon garrisons and to relieve in times of trouble and famine. The toothed half-tablet (*ya chang*), to levy armies and station soldiers and frontier guards; the commentator explaining that this was furnished with carved teeth as emblems of war. The oval tablet (*pi yen*) was used for regulating measures; the commentator saying that this tablet was one foot from above downward and eight tenths of a foot broad, being a *pi* made not round for regulating measures of length. Again: He ties silk cords through the holes pierced in the *kuei*, half-*kuei*, circular, octagonal, tiger-shaped, and semicircular tablets, and lays aside the round and octagonal tablets placed in the coffin; the commentator explaining that channels and holes were driven through the jade of all six kinds, through which strings were passed to tie them to the corpse; the *kuei* being tied on the left side, the half-*kuei* at the head, the tiger tablet on the right, the semicircular one at the feet, the circular tablet under the back, and the octagon on the abdomen; a cube figuring a microcosm, emblem of the god of the universe. The grain tablet (*ku kuei*) was used to arrange disputes and as a betrothal present. The rounded tablet (*wan kuei*), to reward virtue and to cultivate good relations; the commentator Chêng observing that this tablet had no sharp edge or point in symbolism of its uses. The pointed tablet (*yen kuei*), to change men's conduct and to punish wickedness; Chêng saying that it had a sharp edge and a point, in token of its use to punish crime and to extirpate rebellion. Whenever there are ceremonies for the entertainment of guests, he prepares the jade objects and brings them. These are all regulations for the proper use of the various jade symbols, and we find, also, in the "K'ao-kung-chi," a section on the jade-workers whose sole duty it was to make these jade tablets.

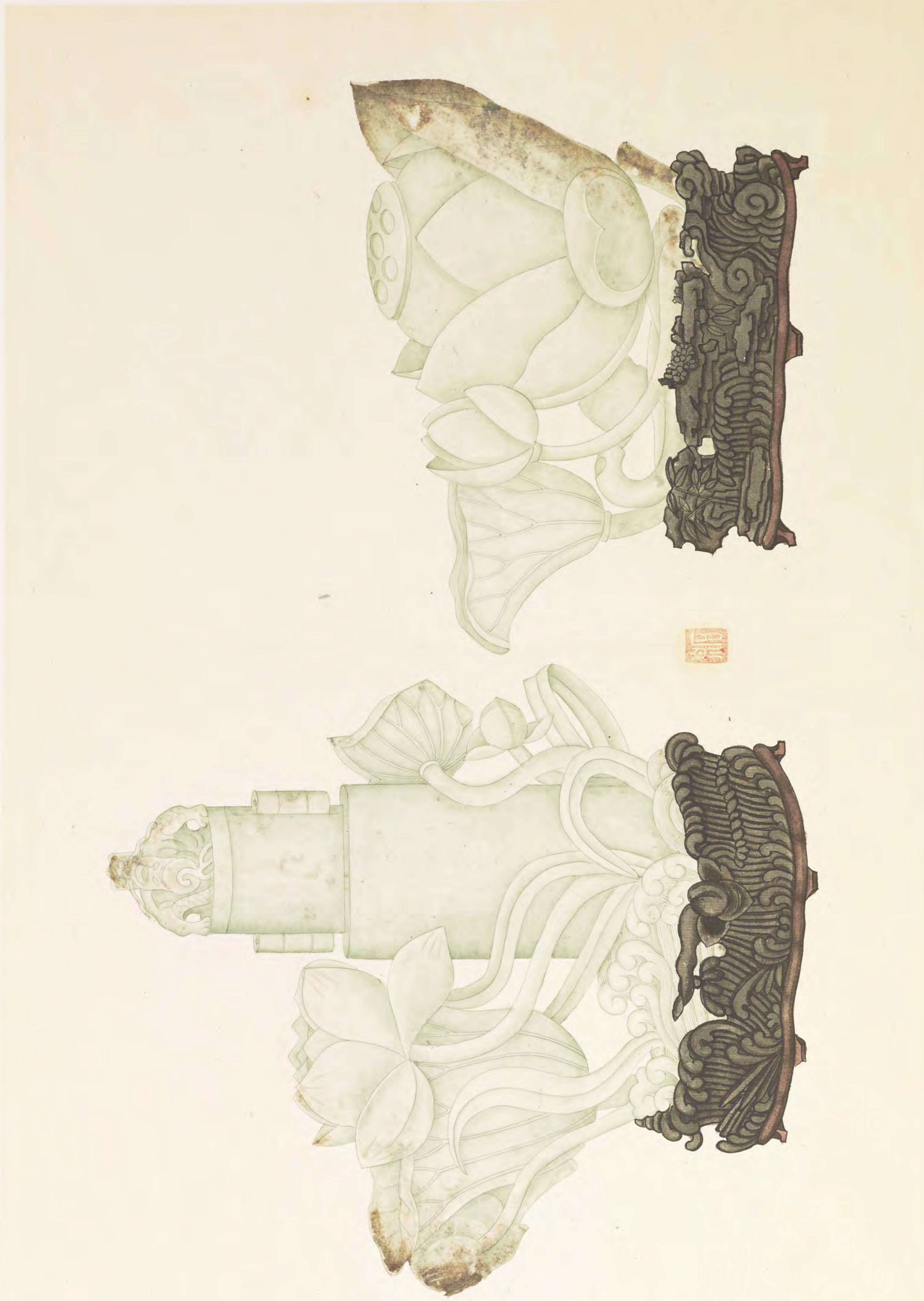
The "Classic of Rites," in the section "Yü tsao," says that dukes and marquises wore in their girdles black jade with hills engraved upon it, tied with red silk cords; the chief officers wore dark-green, wavy jade with black and white silk cords; the scions of the royal house wore jade-like jasper with blue and white silk cords; the scholars wore another stone resembling jade with red and yellow silk cords.

The "Book on Sacrificial Worship" in the "Former Han Annals" describes the officers in charge as offering the jade *hsüan*, explained by the Commentary to mean round tablets of jade (*pi*) six tenths of a foot in diameter. The "Han Chün" says that the emperor Wu Ti in the first year of the Yuan-shou period (B. C. 122) ordered to be made by the government the tiger tablets for military officers. Princes of the blood and nobles used jade tablets; state governors, copper tablets. These were numbered with the characters of the cycle of ten; the left half was kept in the capital, the right half given to the officer in command; and whenever an expedition was sent to put down a rebellion, they first compared the two pieces of the tablet. The "Book on Official Robes" says that, according to the Han regulations, princes and dukes wore caps of jade in eight lobes; marquises, barons, the sons-in-law of the emperor, and mandarins of the first grade, seven-lobed jade caps; of the second grade, six-lobed jade caps; of the third grade, gold caps (or crowns), or five-lobed caps of dark-colored jade. The "Miscellanies" of the Western Capital say that, according to the Han regulations, princes and dukes were both buried in jewelled robes and jade chests. A book on events in the Annals of the Chin dynasty records that when the heir to the throne first had audience the emperor presented him with a jade unicorn tablet. The Memoirs of the T'ang emperors record that Kao Tsu first fixed the official rules for girdles. The girdles of the hereditary nobles, the princes and dukes, of commanders-in-chief and ministers of state, were mounted with thirteen plaques of jade, and had two additional pieces hanging down behind.

Under the reigning Manchu dynasty, at the sacrifices in the ancestral temple and in the second hall of the ancestral temple, as well as in the principal ceremonies at the altar of the gods of the land and grain, libation-cups of jade are always used. The Government Statutes of the Great Ch'ing include among the jade objects used in sacrificial worship round tablets (*pi*), octagonal tablets (*tsung*), and *kuei*. In the principal ceremonies at the Temple of Heaven dark-colored *pi* are used; in the principal ceremonies at the altar of earth are used yellow *tsung;* on the altar of the gods of the land and grain, in the worship of the chief god, white *kuei* sprinkled with yellow; in the worship of the chief god of grain, green *kuei;* on the altar of the sun, red *pi*, and on the altar of the moon, white *pi*. All the carefully designed patterns of jade objects used by the state are here published, so that the ritual may be established and fixed.

VII. THE COLORS OF JADE

Jade is naturally one of the most beautiful substances created by heaven, and it is highly prized by scholars. There are many different kinds described, the colors being distinguished according to their high or low value. The encyclopædia "Ch'ien-ch'o-lei-shu" describes jade as being of five colors. "The three colors, white, yellow, and green, are all highly valued. The white of fresh lard is the most valuable; that like rice-water, with oily stains, and that with marks like snow, being inferior. Of the yellow, the most precious is of the color of chestnuts, which is called pure (literally, sweet) yellow, the smoky yellow being inferior. Of the dark-green color, the best is of deep bluish-green tint; if sprinkled with fine black stars, or if pale in shade, it is less valuable. There is also a red jade, red as a cock's comb, which is considered the most valuable kind of all, but this kind of beautiful jade is of extremely rare occurrence. Green jade, when of a deep-green color, is considered precious, the pale being inferior; transparent-green jade is of a pale-green color, with a tinge of yellow; spinach jade, being neither transparent nor of rich-green color, but of the shade of the leaves of the vegetable, is the least valued of all. The ink-black jade is also of no great value." It says, again, that "red jade is called *mên*, and is also called *ch'iung*, the last name conveying the additional meaning of translucid; that brown jade is called *tzŭ;* half white and red, *juan;* bright-green jade, *lu;* dark-colored, *yi;* black jade, *chioh;* black jade of which mirrors can be made, *chin*." Again, Wang Yi's book on jade, "Yü-lun," describing the colors of jade, includes red as the cock's comb, yellow as boiled chestnuts, white as freshly cut lard, black as pure lac, these being called jade tests; but there is no mention here of



No. 621

VASE WITH COVER

(*Kai P'ing*)

Ch'ien-lung (1736–95)

Nephrite

No. 620

WATER RECEPTACLE

(*Shui Ch'êng*)

Ch'ien-lung (1736–95)

Nephrite

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green jade. In the present day the green and white colors are very common, and black is occasionally met with, but the red and yellow hardly exist; so that, even for the six vessels of sacrificial worship, it is impossible always to find genuine pieces.

Yi-chou produces a kind of stone of the color of boiled chestnuts, which is called by the natives chestnut jade, and is supposed by some to be a kind of yellow jade, but it is wanting in brilliance and translucency, and fails to give out a clear, resonant sound when struck, so that others say that this chestnut jade of Yi-chou is only a brilliant, translucid kind of common stone, not really jade. Jade is hard, and its polished surface cannot be hurt by fire or edged weapon, whereas this kind of yellow stone can be easily carved by a small knife, and it is similar in structure to the white stone of Chieh-chou, though different in color.

Shih-chên (in the "Pên Ts'ao") says that, according to the "T'ai-ping Yü Lan," white jade came from Chiao-chou, red jade from Fu-yu, green jade from Yi-lou, spinach-green jade from Ta-ch'in, black jade from Hsi-shu, fine jade, in color like indigo, from Lan-tien, whence the place derived its name. Huai Nan Tzŭ says that the jade of Chung Shan could be heated in a charcoal stove for three days and nights, without any change of color, because it was endowed with the pure essence of heaven and earth. In the Ancient Rites, the green tablet (*kuei*), the dark cærulean *pi*, the yellow octagonal *tsung*, the red *chang*, the white tiger-shaped *hu*, and the black, semicircular *huang*, all derived their names from the symbolism of heaven, earth, and the four quarters.

In the present day white is the color most sought after in jade, and modern amateurs of jade generally keep a set of patterns for comparison. These patterns are little oblong tablets carved out of the purest and finest jade, arranged according to their colors by a clever connoisseur, in a set of ten, numbered in correspondence with their respective values. Whenever a piece of jade is added to the collection, these patterns are brought out and compared with the color of the piece, so that it may be put into one of the ten classes. The rarest kind of all is white and translucid, like mutton fat, tinged with faint pink throughout, and this is called the tenth grade of the colors. This is, however, of the greatest rarity and very seldom seen, so that a dealer in jade, in his whole lifetime, may not succeed in getting a single specimen, and should one piece be found out of ten thousand, it is cherished as a jewel of rare price and of inestimable value. The next in value are placed in the ninth grade, then come the eighth and seventh, down to the least valuable pieces, included in the second and first grades. The pieces of fine white jade in ordinary collections belong generally to the fifth and sixth grades, for not only is it difficult to become the fortunate possessor of a specimen of the tenth grade, but examples even of the ninth and eighth grades are not easily found.

Ink-black jade is black throughout like ink. When its substance is entirely translucid and shines brightly like a mirror, without brain-like marks or spots of any other color, it is good; if the color be pale or not uniform, or dull and not brilliant, it is inferior. There is another kind of sprinkled ink-black jade, commonly known as ink-spot jade. This is of white body, with black spots, as if made by sprinkling with a brush dipped in liquid ink, and when the spots are clearly defined and regularly distributed through the mass it is valuable; but if the darker portion be not broken up into spots, or if the lighter part be surrounded by a halo, in neither case is it worth having. There is another kind of jade which is half black, half white, the two colors united in one piece with lines of demarkation sharply defined; the one white as lard, the other black as ink, not mixing with each other. When this comes into the hands of the worker in jade he plans a special design according to the size and color, and carves the piece, and often succeeds in producing a clever work of art, imitating a spontaneous growth of nature. Thus are formed rare pieces of unrivalled skill, and this peculiar kind of artistic work is worthy of a collector of culture.

Among white jades there is one special variety invested with a skin. This kind comes from Ho-tien (Khotan), and is found in the rivers among the best jade pebbles produced there. It seems that the stones which are found in the river have been rolled down by the current, and after the water has subsided they lie exposed in the bed of the river, to be burned by the sun and blown about by the wind, acted on by the water and rubbed by the sand, till after a long time a coat is formed on the jade, a kind of light-reddish skin, the color of an autumn pear, which is called russet pear-skin. This skin may enclose a jade of either good or bad quality. In the present day, snuff-bottles, thumb-rings for archers, tubes for peacock's feathers, mouth-pieces for tobacco-pipes, etc., are often carved out of this kind of jade, and are twice as valuable as those made

of the ordinary varieties. But the color of the skin must be exactly like that of the rind of the russet pear; if deeper or lighter in the tint, it is not esteemed.

The dark-green jade (*pi-yü*) which comes from the southern border (of China) is of a very strong and hard body but dull in color, and it is also often variegated with brain-like marks. It occurs, however, in very large and heavy pieces, like the fish-bowl (*wêng*) of jade which stands in the Prohibited Grounds in front of the Chêng Kuang Palace,[1] which is between six and seven feet in diameter, so that a man can lie down at full length inside. This is considered valuable only from its unusual size.

With regard to yellow jade and clear-green jade, good specimens are seldom seen, and they are generally valued in proportion to the purity of color and bright translucency, the inferior kinds being dull and mixed with other shades. Vegetable jade is a variety of green jade, of deep-green color like spinach, from which it derives its name. The dealers call this kind Ma-na-ssŭ. Ma-na-ssŭ (Manas)[2] is the name of a Mohammedan walled city in the New Dominion (Turkistan), which gives its name to jade because the spinach jade is a product of that place, and hence it is called by the same name as the city.

VIII. ANCIENT JADE

Scholars of the present day who love antiquity and learned research all consider ancient jade to be the rarest of treasures. Ancient jade is jade that has lain buried in the earth and been discovered again. The jade has lain buried in the ground, either lost in times of famine, or sunk in water during an inundation, or when lakes were being planted with mulberry trees and reclaimed. Sometimes it has been purposely buried and subsequently forgotten, at other times overwhelmed by falling mountains or fallen into earthquake cracks. It may have remained hidden in the bowels of the earth for centuries until it is found again, when it is submitted to skilful manipulation and becomes a valued specimen of ancient jade. The process of manipulation of ancient jade is to put it into a cotton bag filled with bran and to submit it carefully to daily friction for some months, or even years, till the old substance of the jade shall appear, when the work is finished.

Han yü, literally jade held in the mouth, was originally used for the jade that in ancient times used to be put into the mouth of the corpse when laid out for burial.[3] Some scholars of the present time, however, apply this term not only to jade found in tombs, but also include under it all ancient jade that has been buried in the earth; others err more deeply still, in writing it as jade of the Han dynasty; both these views are, in my opinion, wrong. In ancient times they often buried jade with dead bodies because of its beauty and high value. It was also employed in former times because when mercury was used to preserve the dead the quicksilver, being liquid, tended to flow out, and had to be sealed up by the addition of jade, so that jade was employed to close up all the orifices of the body to prevent the mercury injected into the corpse from escaping. But the jade thus put into dead bodies must get stained by them. In this way the material, as it lies buried in the ground for long years, becomes gradually decomposed and rotten, so that other substances can penetrate and discolor it—that is what is called "staining." The jade, originally of pure-white color and perfectly translucid, after having been stained in the corpse, cannot but have its purity soiled, so that this kind is not so highly valued as other ancient jades. When jade has been buried for over 500 years the stains penetrate its substance; after 1000 years it becomes as soft as common stone; after

[1] This palace is in Peking, within the Imperial City, on the eastern bank of the lake, where it is spanned by a marble bridge. The foreign envoys have had their audiences with the emperor of late years in one of its halls. The immense bowl referred to stands in the grounds, outside the audience-hall. It is of oval shape and rounded section, with a round mouth, the diameter of which is about two thirds of that of the middle of the bowl. It is said to date from the Yuan dynasty (1280–1367), when the palace was founded, and to have occupied the same place ever since.

[2] The city takes its name from the river Manas, which has its five-fold source on the northern slopes of the lofty Khatun Bogda Mountains and runs north to the lake Ebi Nor. Gold as well as jade is found near its source. This river is also called by the Chinese Ch'ing Ho, or Clear River, on account of the transparent purity of its current. The jade found here, according to Ying-ho (Hsi Yü Shui tao chi, Book III, fol. 34), is of a translucid, very dark-green color with mottled stains. It is described by him as obtained from the river-bed, where it occurs in blocks, the largest of which weigh several tens of catties. A similar kind of jade is found at Batugol, near Irkutsk in Siberia, specimens of which have been sent to all the museums of Europe by M. Alibert. One of these, an immense water-worn block of irregular ovoid form in the British Museum, is four feet long and weighs 1156 pounds. There is a small polished bowl (No. 806) in the Collection, and a series (Nos. 101–133) of mineralogical specimens of Siberian jade.

[3] The custom of placing something precious in the hand or mouth of a corpse is ancient and wide-spread. The Romans used to put an *obolus* under the tongue of the deceased as a fee for Charon for his ferry over the river Styx, and even in the present day, at an Irish wake for instance, the dead has a piece of money put in his hand to pay his way with. In Mexico a carved piece of jadeite was inserted in the mouth of the corpse of a noble in ancient times, before the Spanish conquest of the country.

2000 years, as soft as lime; after 3000 years, as soft as decayed bone, this being the extreme limit of the life of ancient jade, so that it is no use looking for jade anterior to the first three dynasties. Ancient jade when first dug up from the ground is called "salt-meat bones"; after it has been handled for a long time the jade recovers some of its old translucency, and it is called "salt-meat skin," these two names being derived from its color and general aspect. When it has been still further manipulated in the bran-bag it is known as shelled ancient jade; this name meaning that the jade, which, while buried in the ground for some thousands of years, has been corroded by the earth and stained by other things till it is as rotten as decayed bone, after having been dug up and submitted to friction and manipulation becomes once more translucid and brilliant, and has its impurities all cleared away, till it comes out of the bran-bag as brilliant and pure as a precious stone, the rottenness being at one stroke all "shelled" off.

Jade which has been corroded by the earth becomes loose and rotten in texture, so that mercury is able to soak through the skin and stain it. In every place there is always some mercury in the ground, so that it is not only that put into the body in ancient times. Once the mercury has soaked in, lime, earth, and various other substances can in their turn soak through and penetrate to the interior. Many substances thus gradually soak through and make stains of many different colors. Some stained by yellow clay becomes yellow in color; some stained by turpentine, of a still deeper tint, and this, after manipulation, comes out of the color of amber and is known as "old dry yellow." Some stained by lime is red in color, and this by friction becomes like the blossom of a double peach, and is known as "child's carnation." Some stained by indigo is blue in color, from the dye of the clothes having soaked through, and this, which may be either light or dark in tint, is known as "old dry blue." Some stained by mercury is black in color, but it can acquire this color only when a large quantity of mercury has soaked in — meaning by a large quantity of mercury so much as used to be put in the corpses of ancient kings and princes, not the mercury naturally present in the ground and the effect of which must be distinguished. After friction this color comes out like the blackest metallic paper, and is known as "pure lac black." Some stained by human blood is crimson in color, — that found in dead bodies for instance, which may be dark or light in tint, and which is known as "jujube red." Some stained by bronze objects is green in color, because bronzes when buried for long years become green and blue, and stain the jade lying beside them of the same colors, like the tint of the kingfisher's feathers; and this, when it has been submitted to friction in the bran-bag, comes out of a yet more beautiful color, not to be surpassed, and is known as "parrot-green." Specimens of this beautiful variety are rarely seen in collections, and are most highly prized. In addition to these there are other colors, caused by the staining of different substances, of so many kinds that they cannot be separately described. Among the names of the colors are vermilion-red, cock's-comb red, grape-purple, aubergine-purple, hibiscus-yellow, chestnut-yellow, pine-green, salisburia-green, mutton-fat white, rice-husk white, shrimp-spawn green, and mucus-green, these last two greens being found only from staining in ground of the south. These rare kinds of different colors are all included under the general name of "the thirteen colors."

There are other cases of staining that produce peculiar transformations like the mottling of a toad's skin, like cloud masses, like crackle-porcelain, like bullock's hair, like crab's claws, or like scattered pearls. The origin of all these different stains is truly most difficult to distinguish precisely. Ranging in space through myriads of miles, and in time some five thousands of years, over a vast territory with all kinds of productions, and buried, moreover, in the depths of the earth to be transformed under the source of the water-springs, — even though a scholar were learned in physics, yet all his knowledge would not suffice, nor would his cleverest guesses be able, to solve such a problem, and there would be places that could not be reached.

IX. FEI-TS'UI

Fei-ts'ui is originally the name of a bird (a kingfisher, *Alcedo halcyon* or *ispida*) found in Yü-lin (in the province of Kuangsi), the cock being reddish and called *fei*, the hen bright green and called *ts'ui*. In the present day the name is applied to green jade on account of the similarity of the color, but it is not known from which dynasty it starts. In the "Ku'ei T'ien Lu" we read that "Ou-yang Hsiu[1] had in his house a large jade bowl

[1] Celebrated among the foremost statesmen of the Sung dynasty, and author of many historical and critical works. Flourished A. D. 1017–1072.

(*wêng*) of most antique aspect and workmanship and artistically carved, which, when he first got it, was pronounced by Mei Shêng-yü to be of ordinary green jade (*pi-yü*). While living at Ying-chou he often showed this bowl to his visitors, and there happened to be sitting there one day a military officer named Têng Pao-chi, an old eunuch of the court of the emperor Chên Tsung, who knew what it was and said: 'This is the precious jade which is called *fei-ts'ui*. Among the precious things preserved in the palace of the Yi-shêng Treasury there was a *fei-ts'ui* wine-cup (*chan*), from which I first came to know it.' Happening one day afterward to rub lightly a gold ring along the interior of the bowl, the gold was gradually rubbed off, just as a cake of ink is rubbed down on a stone pallet, whereby it was first known that *fei-ts'ui* could reduce gold to powder. Thus we see that the name of *fei-ts'ui* was applied to green jade as early as this time (eleventh century A. D.)."

The *fei-ts'ui* of modern times is found in Burma (Mien-tien kuo) in the midst of high mountains. It occurs in the middle of the rocks, and natives first chisel out of the rocks the rough jade, which is found in masses varying in size up to the weight of a thousand or even ten thousand catties. These are very coarse in appearance and color, brownish-yellow like the outside of a salted ham, and would be taken by an ignorant man for blocks of common stone. The places have long been worked, and the superficial and easily worked parts are exhausted, so that the finest jade is inside, and it is necessary to dig deep down to extract any. But mining so deeply and groping in the dark are hard tasks for the laborers, and recently the novel method of blasting the rocks by gunpowder has been introduced and has taken the place of other manual labor. By this method, when the overseer has discovered a place containing pieces of *fei-ts'ui*, he directs the miners to drive in tunnels below the mountain to the depth of some five or ten feet, and to fill them with blasting-powder. The mouths of the tunnels are then sealed, and the powder exploded in the ordinary way. The mountain falls and the rocks are split, and the *fei-ts'ui* can be afterward picked out. But the jade got in this way is generally much scarred and cracked, so that large perfect pieces are rarely obtained; and the new material of modern times is very often marked with willow-like scars for the same reason.

After it has been mined it is necessary to examine closely the texture and veins, and to look carefully for traces of color, holding it up to the light of a lamp or the sun to see if any shade of green is reflected from the interior, a sign that there is hope of its containing *fei-ts'ui*. It is then given to the workers in jade to be sawn open, and if of pure emerald-green color, clear and translucid, neither oily nor dry, and without spots and scars, of wholly translucid body, and color both deep and full, it is considered to be of the highest value. When on a ground of pure white there are sprinkled some spots of deep green, instinct, as it were, with life and movement, sharply defined and not shading down, of clear translucency without flaw, it is known as "pretty green," and is also of high value. When, on the contrary, the green color is either pale or clouded, or although deep yet approaching black, or when the white color is gray like the ashes of a joss-stick, or cloudy like a bad stone, all these varieties are not worth collecting. There is another kind in which the whole body is pale emerald-green, and which at first sight appears to be valuable, but on more careful examination the color disappears and leaves no clear trace behind, so that it is impossible to define exactly the green part. When the green color is strewn with black spots, or when it is mixed with white flecks, it is also included in the category of common stuff.

There are other differences in the rough ore, depending on its coming from old mines or from new mines. The *fei-ts'ui*, growing in the bowels of the rock, becomes gradually formed inside and develops in the dark its brilliant color during an unknown succession of years, till it becomes fully formed into perfect jade. When the full time has elapsed, the power of growth being so great, it is organized into a perfectly formed specimen. Hence, when weighed in the hand it is of heavy specific gravity, and when tested by the eye its colors are fully developed. The innate power of growth has produced a kind of deep, full, and rich tone, penetrating and veining the whole substance; and this is known as "old mine ore." But when the green is only of some days' growth and not fully formed, and it is dug up prematurely and so prevented from attaining its perfect development, the color, even if fairly good, fails to show the full rich brilliance, the texture is light and loose, and the body wanting in strength and firmness; and this is known as "new mine ore." To determine whether a piece be of new or old ore, and to distinguish accurately the rich and the immature state, require the practised eye of a connoisseur, and the distinctive points can only be generally

09

No. 459

ARCHAIC LIBATION-CUP

(*Ku Chüeh*)

K'ang-hsi (1662–1722)

Nephrite

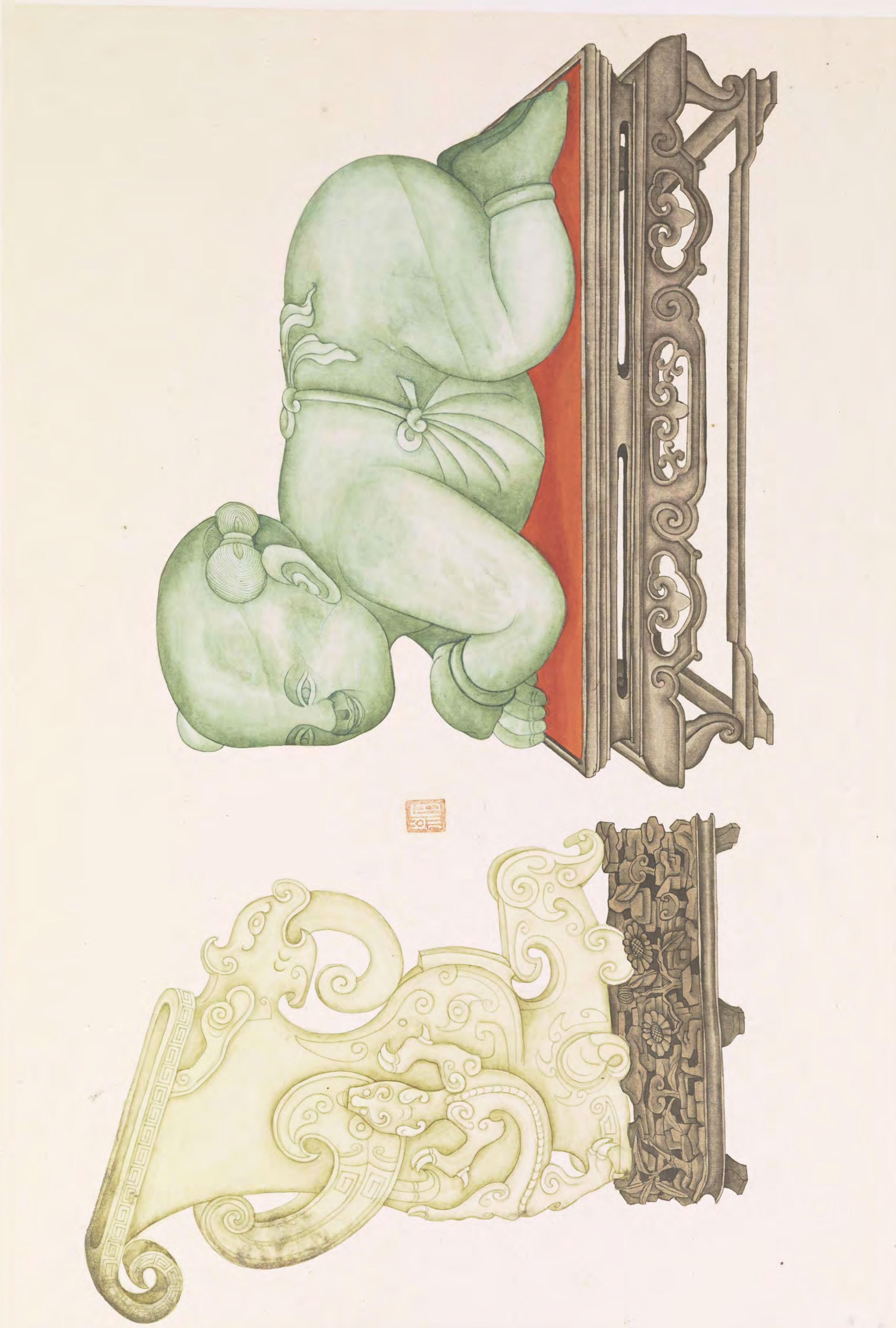
No. 426

BABY PILLOW

(*Wa-wa Chên*)

K'ang-hsi (1662–1722)

Jadeite



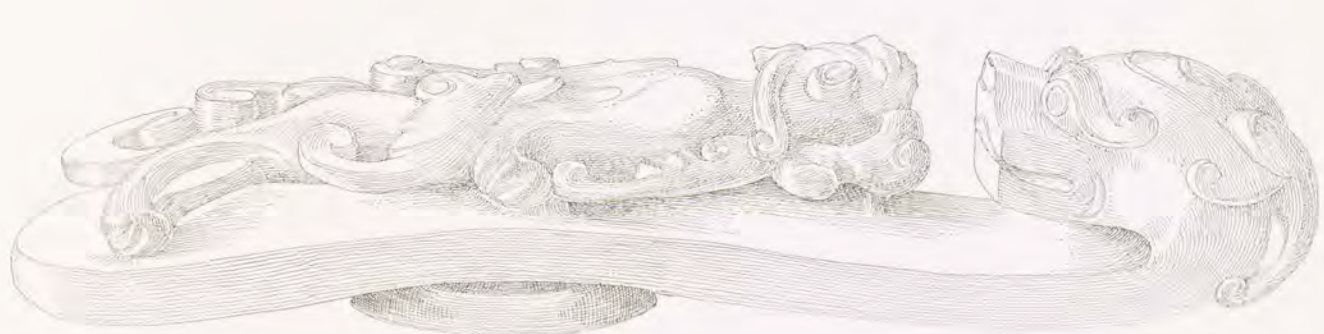
sketched, as it is impossible to describe them exactly by the pen or by word of mouth. When, however, the worker in jade comes to carve the piece, it can easily be distinguished as new or old, because the old, being of hard substance, requires much labor; whereas the new ore, being of soft body, is more easily worked, so that the mere act of splitting it open is sufficient to determine its real nature.

After it has been carved into a work of art and polished to a brilliant surface, the color shines out in its full beauty, and gives the artistic work a rare value, so that it excels in color the waves of spring and in brilliance the precious emerald. Put into water, its green color permeates the whole mass; placed on the table, its powerful brilliance dazzles the eyes. This is the most precious kind of *fei-ts'ui;* its beauty is such that an ordinary man hardly ventures to keep it in his private possession.

With regard to the various things made of it, there may be seen in the imperial grounds melons carved out of *fei-ts'ui;* and there are exhibited in the rooms of the palace vegetables (cabbages), as if growing there. There are flower-vases, fruit-dishes, bowls, and wine-cups for the decoration of the banqueting-table; ear-jewels, hair-pins, and rings for the daily adornment of beloved beauty. For appendages to be worn with the official robes, there are tubes for the peacock's feather and beads for the rosary; for personal adornment, there are pins for the hair and rings for the archer's thumb. Rests for the pencil-brush and cylindrical vases for holding paint-brushes light up with their beauty the study of the scholar; tobacco-pipes and snuff-bottles are cunningly carved for the rich and luxurious. The value of a pair of bracelets to encircle the arm will exceed a thousand ounces of silver; the price of a single buckle for a girdle round the waist will amount to several hundreds. The eighteen beads (of the small rosary), the number of the Buddhist Arhats (Lohan), are rich jewels for the breast; the two-headed pins, for winding the hair round, make bright ornaments for the crown of the head. Other things, like the ornaments and Buddha's heads hung as appendages upon the rosary, the flower-petals and butterfly-wings sewn upon velvet on the head-dress, although of very minute size, are valuable when of brilliant color. Specimens of the highest class are really equal in value to "several walled cities"; they are the special product of the miraculous creative power of hills and rivers, and are cherished as precious jewels by rich men of the present day.

Some say that jade when red in color is called *fei,* when green in color *ts'ui,* after the names of the differently colored kingfishers; but the red jade is of very rare occurrence, and so the general name of *fei-ts'ui* is applied to green jade. In former times, however, there existed a kind of jade, each piece of which exhibited the two colors, red and green, both so pure and bright as to dazzle the eyes, and this was really worthy of the name.

With regard to the green bowl in the possession of Ou-yang Hsiu described in the "Ku'ei T'ien Lu," which was able to reduce gold to powder, the *fei-ts'ui* of modern times, when carved and polished, is bright, smooth, and of fine surface, and therefore incapable of pulverizing the different metals, from which it may perhaps be inferred that the precious jade called *fei-ts'ui* at that time may be different from that known as *fei-ts'ui* in the present day.



APPENDIX

TITLES OF SEVENTY-ONE CHINESE BOOKS QUOTED IN THE DISCOURSE ON JADE

1 *Shu Ching.* Classical Book of Annals. Compiled by Confucius about 500 B.C. Translated by Dr. Legge, Chinese Classics, Vol. III, Parts 1, 2.

2 *Chou Li.* Ritual of the Chou dynasty (B.C. 1122–249). With an appendix, *K'ao-kung-chi*, on various handicrafts. Said to have been written about 1100 B.C. Translated into French by Biot, 1851.

3 *Li Chi.* Book of Rites. One of the Five Classics.

4 *Po-wu-chih.* Records of remarkable objects, by Chang Hua, A.D. 232–300, a native of Fan-yang (near the present Peking).

5 *Huai Nan Tzŭ.* A Taoist work by a descendant of the first emperor of the Han dynasty, named Liu An, Prince of Huai Nan, who died 122 B.C.

6 *Yü-ching-t'ou.* Illustrated Book on Jade Mirrors. Author unknown.

7 *Yü Shu.* An old book on Jade. Author unknown.

8 *Pên Ts'ao.* Standard works on Materia Medica collected in the well-known *Pên-ts'ao-kang-mu*, in 52 books, by Li Shih-chên of the Ming dynasty. Sixteenth century A.D.

9 *Yi-wu-chih.* Record of strange things, by Yang Fu, of the Sui dynasty, A.D. 581–618.

10 *Pieh-pao-ching.* Classic of various precious things.

11 *Chang Kuang-yi Hsing-chêng-chi.* Record of the itinerary of Chang Kuang-yi, who was sent on an embassy to Khotan by the first emperor of the After Chin dynasty in the year 938. He was sent again to Khotan by the founder of the Sung dynasty in 961. (Histoire de Kotan, par A. Rémusat, pp. 74–83).

12 *Sou-shên-chi.* A Collection of Legends by Yü pao, who lived in the early part of the fourth century.

13 *Êrh Ya.* An ancient Dictionary of Terms used in the Classics, divided into 19 sections, each treating of a different class of subjects.

14 *Hsi-yü-wên-chien-lu.* A description, in 8 books, of Eastern Turkistan and neighboring countries, by Ch'i Shih-yi, a Manchu officer, published in 1777.

15 *Fu-jui-t'ou.* An illustrated book on Jade Talismans, etc., by Hsü Shan-hsin of the sixth century.

16 *Yün-hui.* A dictionary compiled by Hsiung Chung of the Yuan dynasty, thirteenth century.

17 *Hsiang Yü Shu.* A book on Jade. Author unknown.

18 *Tao Tê Ching.* The famous classic of the Taoists, by Lao Tzŭ, written at the close of the sixth century B.C.

19 *Han Fei Tzŭ.* The works of Han Fei, a philosopher of the third century B.C.

20 *Hsien Ching.* A Taoist book of medical prescriptions, quoted in the *Pên Ts'ao.*

21 *Shih Ching.* The Classic Book of Odes, compiled by Confucius about 500 B.C. Translated by Dr. Legge, Chinese Classics, Vol. IV, Parts 1, 2.

22 *Wu-yin-chi-yün.* A dictionary by Han Tao-chao of the Chin dynasty, twelfth century.

23 *Shuo Wên.* The celebrated ancient dictionary by Hsü Shên, written at the close of the first century A.D.

24 *Pai Kuan.* By Ch'ou Yuan, Yuan dynasty, twelfth or thirteenth century.

25 *Ch'ien Han Wang Mang Chuan.* The life of the usurper Wang Mang (A.D. 9–23), in the History of the Former Han dynasty.

26 *Hsi-ching-tsa-chi.* A record of incidents at Ch'ang-an, the metropolis during the Han dynasty, by Liu Hin, who lived about the beginning of our era.

27 *Tu-yang-tsa-pien.* A record of rare and curious objects brought to China by Su O from A.D. 763–872. Latter part of ninth century.

28 *T'ien-pao Yi-shih.* Matters omitted in the annals of the T'ien-pao period (742–756). By Wang Jên-yu. Tenth century.

29 *Yu-yang-tsa-tsu.* Essays on the productions of China and foreign nations, etc. In 20 books. Written by Tuan Ch'êng-shih toward the end of the eighth century.

30 *Yi-chien-chi.* By Hung Mai, a celebrated writer of the Sung dynasty, who lived A.D. 1123–1203.

31 *Shih Chi.* Historical records, by the famous historiographer Ssŭ-ma Ch'ien, B.C. 163–85.

32 *Tso Chuan.* Amplification of the ancient annals of the state of Lu, in the present province of Shantung, extending from 722 to 484 B.C. By Tso Chiu-ming, one of the disciples of Confucius.

33 *Han Wu Ku-shih.* A record relating to the time of the emperor Wu Ti, B.C. 140–86, attributed to Pan Ku. Others believe it to be a compilation of the T'ang dynasty.

34 *Ho-t'ou-yü-pan.* Seems to be a production of the Han period. It is quoted in the *Po-wu-chih.*

35 *Shih-chou Chi.* A fabulous description of ten insular kingdoms attributed to Tung-fang-so. Second century B.C.

36 *Pao Fu-tzŭ.* A work on Taoist philosophy, alchemy, charms, etc. By Ko Hung. Third and fourth centuries A.D.

37 *Mêng Tzŭ.* The works of Mencius, fourth century B.C. Translated by Dr. Legge, Chinese Classics, Vol. II.

38 *Han Shih.* History of the (Former) Han dynasty, 202 B.C.–25 A.D. Compiled by Pan Ku, who died 92 A.D.

39 *San-fu-huang-t'ou.* An ancient description of the public buildings in Ch'ang-an, the metropolis of the Han.

40 *Wei Shih.* History of the Wei dynasty, A.D. 386–558. Compiled by Wei Shou.

41 *Hu Tsung Pieh-chuan.* Biography of Hu Tsung in the *San Kuo-chih*, or History of the Three Kingdoms (A.D. 220–280), book 62.

42 *Yi Yuan.* By Liu Ching Ching-shu, of the Liu Sung dynasty. Fifth century.

43 *Liang-chou Chi.* Description of the province of Liang-chou (the modern Kansu). Fourth or fifth century.

44 *Shih-yi Chi.* Record of things omitted in the annals of the empire, by Wang Chia. Fourth century.

45 *Nan Shih.* Southern History. A.D. 420–589. Compiled by Li Yen-shou.

46 *T'ang Liu Tien.* Canons of the Six Boards of the T'ang dynasty, in 30 books, drawn up by the emperor Yuan Tsung in the early part of the eighth century.

47 *T'ang Shih.* History of the T'ang dynasty, A.D. 618–907, by Ou-yang Hsiu.

48 *Sung Shih.* History of the Sung dynasty, A.D. 960–1280. Compiled by T'o T'o.

49 *Hsü Wên Hsien T'ung K'ao.* Supplement to the *Wên-hsien-t'ung-k'ao* of Ma Tuan-lin, compiled by Wang Ch'i in 1586, in 254 books.

50 *Chin Shih.* History of the Chin dynasty, A.D. 1115–1234. Compiled by T'o T'o.

51 *K'ai Shan T'ou.* An old book, quoted in the *Ku-yü-t'ou*, describing how Yü Wang opened the country after the inundations.

52 *San Li T'ou.* Illustrations of the Three Rituals, by Liu Ling, fifteenth century.

53 *Lu-p'u-chi.* Description of the imperial travelling equipage.

54 *Mu T'ien Tzŭ Chuan.* A narrative of the adventures of the emperor Mu Wang (1000 B.C.) on his journey to the West. Said to have been found in the tomb of one of the Wei princes in A.D. 281.

55 *Ch'uan Kuo-hsi K'ao.* Researches on the seals of succession to the empire.

56 *Han Chiu-yi.* Old usages of the Han dynasty, quoted in the *Ku-yü-t'ou.*

57 *Han Shu Fu Chang-chih.* Description of official robes in the Han History.

58 *Han Shu Yü-fu-chih.* Description of the imperial carriages and equipage in the Han History.

59 *T'ang-shih Lu.* Lives of the emperors of the T'ang dynasty, A.D. 618–907.

60 *Ming-huang Tsa-lu.* Records of the reign of Ming-huang (713–755). By Chêng Ch'u-hui, T'ang dynasty.

61 *Kai-yuan Yi-shih.* Matters omitted in the annals of the K'ai-yuan period (A.D. 713–741), by Wang Jên-yü, tenth century.

62 *Huang Ch'ao Hui Tien.* Statutes of government of the imperial dynasty. Sung dynasty, A.D. 960–1280.

63 *Ch'ien Han Chiao-ssŭ-chih.* Description of the sacrificial rites in the Former Han History.

64 *Han Chün.* Discourses on the Han by Lin Yueh of the Sung dynasty.

65 *Chin Shu Chin Shih.* Ancient events in the History of the Chin dynasty, A.D. 265–419.

66 *Ta Ch'ing Hui Tien.* Statutes of government of the Great Ch'ing (the reigning) dynasty.

67 *Ch'ien-ch'o-lei-shu.* A cyclopædia in 120 books, by Ch'ên Jên-hsi, who completed it in 1632.

68 *Wang Yi Yü-lun.* Description of Jade, by Wang Yi.

69 *T'ai-p'ing Yü Lan.* The vast encyclopædia in 1000 books, finished in 977, by command of Tai Tsung, second emperor of the Sung dynasty.

70 *Ku Li.* Description of the Ancient Ritual in the Book of Rites.

71 *K'uei T'ien Lu.* A small collection of incidents, chiefly relating to the imperial court, written by the historian Ou-yang Hsiu after his retirement from office, and published in 1067.

64

No. 351

WINE-JUG

(*Chiu Kuan*)

Previous to Ming Dynasty

Nephrite

Rod. Piguet

YÜ SHUO

A DISCOURSE ON JADE

WITH RESEARCHES ON THE HISTORY OF JADE

玉說引用書籍凡七十一種

書經　周禮　禮記　博物志　淮南子
玉鏡圖　玉書　本草　異物志　別寶經
張匡鄴行程記　搜神記　爾雅　西域聞見錄　符瑞圖
韻會　相玉書　道德經　韓非子　仙經
詩經　五音集韻　說文　稗官　前漢王莽傳
西京雜記　杜陽雜編　天寶遺事　酉陽雜俎　夷堅志
史記　左傳　漢武故事　河圖玉版　十洲記
抱朴子　孟子　漢書　三輔黃圖　魏書
胡琮別傳　異苑　涼州記　拾遺記　南史
唐六典　唐書　宋史　續文獻通考　金史
開山圖　三禮圖　鹵簿記　穆天子傳　傳國璽考
漢舊儀　漢書章服志　漢書輿服志　唐實錄　明皇雜錄
開元遺事　皇朝會典　前漢郊祀志　漢儁　晉書舊事
大清會典　潛確類書　王逸玉論　太平御覽　古禮
歸田錄

翠之瓜、上方蓄像生之茶、瓶盤盌琖、庭敞華筵、璫珥釵環、日親芳澤、佐冠裳之制度、有翎管與朝珠、壯佩飾之觀瞻、得搔頭與搬指、筆床筆筒、耀奇采於文房、烟管烟壺、增豪華之享用、約臂誇雙釧之富、價逾千金、纏腰榮一帶之鈎、亦數百兩、十八子是羅漢之數、富麗當胸、兩頭忙爲挽髻之簪、榮華冠頂、他如配朝珠之背墜佛頭、嵌首飾之花心蝶翅、物雖微細、惟色豔之足珍、品既高超、自連城之是寶、此卽山川靈秀之獨鍾、而爲今日豪華之賞玩焉、或謂玉之有赤色者曰翡、有綠色者曰翠、亦猶鳥之判色異名、惟翡玉不經見於世、故相率以翡翠二字、並名綠玉也、然往昔嘗見玉料、一物之上、具有赤綠二色、並皆鮮豔耀目、是卽名稱其實、再歸田錄所載歐陽修家之翠罌、力能屑金、而今日之翡翠、既經琢磨、光滑細膩、實不能磨屑五金、然則爾時所謂呼翡翠之寶玉、似非今日所稱之翡翠耳、

玉說終

惟所獲之材、率多綻裂鮮得巨璞、今之新料、往往多有痕柳、職是故耳、採取之後、尋索綫路、審視色痕、再映鐙日以覘之、依稀中含綠影者、便可冀其有翠也、迨經玉人鍘剖、以綠色正碧明豔晶瑩、不油不乾、無斑無柳、體質蒼潤、色相沉實者、堪稱寶貴、白綠分明色澤融潤、白如凝脂、綠如滴翠、亦爲佳品、質地純白、濃碧點染、活潑流麗、不散不暈、清澈無滓、是爲俏綠、亦屬上乘、至於綠色或淡而似暈、或濃而近黑、白色或污似香灰、或暗如爛石、皆無足取、又有通體淡碧、初覯品若甚佳、細玩則顏色走散、漫無定踪、轉不能指其綠色之所在、或綠色內雜現黑斑、或攙白屑者、亦屬庸常之物耳、璞料復有老坑新坑之別、翡翠胎於石腹、蘊結中央、隱曜韜光、不知經歷幾何歲月、乃能葆厥太璞、資其化育、長養之功深、斯釀成之品萃、故入手而體質較重、寓目則色相皆蒼、自有一種沉實厚茂之氣、流露於䚡理膚間、是爲老坑料、其有凝綠日淺、涵蓄未深、輒占發覆之爻、頓絕生成之路、色澤雖佳、實乏蒼潤之概、質自輕鬆、體欠堅緻、是爲新坑料、蓋斟酌於新老之間、辨識乎蒼嫩之際、惟在通家之鑒別、是僅可以意會、而非筆墨語言所能形容者、或經玉人切磋、亦可評其新老、蓋老料質堅而用工多、新料體柔而致力少、一經開剖、便可悉其的蘊也、若夫雕琢成器、磨礪滋瑩、色以光而愈麗、工以巧而彌珍、豔奪春波、嬌如滴翠、映水則澄鮮照澈、陳几亦光怪陸離、是爲翡翠之絕詣、而非匹夫所敢懷藏者矣、至其爲器也、 禁苑陳翡

葵黃、栗肉黃、松花綠、白果綠、羊脂白、糙米白、蝦子青、鼻涕青、此二種青色、係南方之
土沁、種種奇形異色、總稱爲十三彩、又有感沁變成巧色者、其花樣有蟾蜍皮、讀如蝦蟆皮
雲霞紋、碎瓷紋、牛毛紋、蟹爪紋、灑珠紋等類、究其受沁之源、實難盡辨、蓋縱橫十
萬里、上下五千年、地大物博、且深藏於廣厚之中、變化於重泉之下、故雖格致之儒、
殫竭智慧、極力揣摩、識見終有莫及之處耳、

翡翠

翡翠、本鳥名、出鬱林、其赤而雄者曰翡、碧而雌者曰翠、今以名綠玉者、亦以其顏色
近之耳、然不知始自何代、歸田錄云、歐陽修家有一玉罌、形制甚古且精巧、始得之
梅聖俞、以爲碧玉、在潁州時、常以示僚屬、座有兵馬鈐轄鄧保吉者、眞宗朝老內臣
也、識之曰此寶玉也、謂之翡翠、寶物皆藏宜聖庫、庫有翡翠琖一隻、所以識也、其後
偶以金環於罌腹信手磨之、金屑紛紛而落、如硯中磨墨、然始知翡翠之能屑金也、
然則呼綠玉爲翡翠、蓋亦有由來矣、今之翡翠、產自緬甸國大山之中、蘊於石內、先
時土人鑿石取璞、大小不一、有重至千萬觔者、形色粗糲、紫黃類火骰皮、不識者視
等頑石、攻取日久、而膚淺易伐者告罄、美料近裏、非深入無所取材、而探賾索隱、人
力難施、近得火藥轟山之法、以代他山之攻、其法由工師察勘翠璞團聚之所、令匠
自山下穿穴、洞入尋丈、實以火藥、塞閉洞口、以法然之、山崩石裂、翠璞亦隨之出現、

本潔白晶瑩、一受尸沁、未免有玷其眞、要不若舊玉之足貴也、玉入土踰五百年沁方入其體、千歲爛如石、二千歲爛如石灰、三千歲爛如朽骨、至此而舊玉之品極矣、然非三代以上之物不能也、初出土之舊玉、名曰臘肉骨、迨得人氣養之日久、玉甦復明、謂之臘肉皮、斯二名者、取其色相近之耳、再加以人力盤足、是謂脫胎、舊玉脫胎者、言玉在土中數千年、爲土蝕物浸、敗如朽骨、出土後得人力盤摩、浸假而晶瑩朗潤、浸假而渣滓一清、比盤摩既成、似寶石之含光純粹、將朽敗之形一旦脫去也、玉既爲土所蝕、體質鬆敗、故水銀能沁入膚裏、地中處處皆有水銀、不獨古人斂尸有之、水銀沁入、則灰土及各種物料、皆能隨之浸滛入內、浸滛之物不同、得沁之色亦異、有黃土沁者、其色黃、有松香沁者、色更深、盤出後色似蜜臘、名曰老乾黃、有石灰沁者、其色紅、盤出後色似碧桃花、名曰孩兒面、有靛青沁者、其色藍、乃衣服之色傳沁、有淺深之不同、名曰老乾青、有水銀沁者、其色黑、非爲厚積水銀所浸、不克有此顏色、所謂厚積水銀、乃古王侯殉斂所用、非地中自有之水銀、不可不辨、盤成後色似烏金紙、名曰純漆黑、有人血沁者、其色赤、卽尸沁也、色有濃淡、名曰棗皮紅、有銅物沁者、其色綠、蓋銅器入土年久、則青綠生焉、玉與之鄰、爲其傳沁、色如翠羽、再加人力盤足、更覺嬌豔無倫、名曰鸚哥綠、惟此種極品、爲人間絕無而僅有者、倘有爲他物所沁之色、品類甚多、莫能悉舉、其名色如丹砂紅、雞冠紅、葡萄紫、茄皮紫、秋

產玉子之絕佳者、蓋玉子產於河內、隨流湧出、水落後、暴露灘間、日晅風散、水蕩沙磨、久久而玉體生膜、膚裹淡赤色、似秋梨、謂之秋梨皮、而皮內之玉亦有臧否之別、今之鼻烟壺、搬指、翎管、烟袋嘴、多有此類琢成者、價亦較常品倍之、然其皮色總以秋梨皮爲定評、過深過淺皆非所善也、碧玉出南徼、質性堅脆、顏色黯然、且多腦性、不甚純潔、惟體質有重大者、如　禁苑承光殿前之玉甕、大徑六七尺、能容一人橫卧、是乃以龐然取貴者也、至黃玉青玉佳品、亦不多見、大致以明淨瑩潤者爲貴、色黯駮雜者次之、菜玉類如碧玉、色深綠似菠菜、故呼爲菜玉、市廛呼爲瑪納斯、瑪納斯者、新疆回城之名也、以之名玉者、因菜玉爲彼處所產、故以城名名之也、

舊玉

方今好古淹雅之士、每以舊玉爲奇珍、舊玉者、入土復出之玉也、玉之入土、或因逃亡散失、或是落水沉沒、或值滄桑致掩、或係埋藏失搰、或山崩遭覆、或地裂被埋、隱閉窮泉、歷刼出世、經人功以法盤成、便爲舊玉妙品、盤舊玉法、以布袋囊之、雜以麩屑終日揉搓撫摩累月經年將玉之原質盤出爲成功、含玉者、古人殉斂實口之玉也、今之君子、不獨僅以殉斂之玉呼爲含玉、舉凡入土復出之舊玉、概稱含玉、甚至訛含玉爲漢玉者、皆非也、古人殉斂多用玉者、以其質美而品超、又因昔時用水銀斂尸、水銀性流走易散、遇玉則凝、故以玉塞諸竅、俾斂尸水銀不能外瀉耳、惟殉斂之玉必有尸沁、玉在土中年久、本質鬆朽、他物浸染、是名曰沁、玉

類、但少潤澤、聲不清越、爲不及也、又或謂儀州栗玉乃黃石之光瑩者、非玉也、玉堅而有理、火刃不可傷、而此種黃石、小刀便可雕刻、與階州白石同體異色耳、時珍曰按太平御覽云、交州出白玉、夫餘出赤玉、挹婁出青玉、大秦出菜玉、西蜀出黑玉、藍田出美玉、色如藍、故曰藍田、淮南子云、鍾山之玉、炊以爐炭、三日夜而色澤不變、得天地之精也、古禮青珪蒼璧黃琮赤璋白琥元璜、以象天地四方而立名、今之玉色尙白、時人蓄玉之家、率藏比子、比子者乃精美玉片、琢成小牌、經通家各就顏色、評定姿格、有自一至十之等第、每獲玉器、輒出比子較對顏色、第其甲乙、以白潤如羊脂而微透淺紅者爲極品、名爲十個頭、顏色惟此種甚稀、世不經見、有畢生玩玉、終其身而不獲一遇者、萬一幸遇、貴等奇珍、不能定其價值、次爲九個頭、爲七八個頭、等而下之、爲一二個頭、間嘗所見之美玉、率皆在五六個頭之間、無論十足之品難以倖求、即七八之材、亦不易覯也、墨玉純黑如墨、以通體瑩澈光潤如鑑、無腦性、無斑駁者爲佳、其色淺、質雜、黯淡無光者次之、又有灑墨玉、俗呼爲甩墨玉、乃白質黑斑、髣髴以帚蘸墨淋漓點灑而成者、以斑點停勻疎密得宜者佳、其濃處不分點、淡處微見暈者、皆不足取也、復有墨白相間之玉、體一色判、界限分明、白既如脂、黑亦似墨、各不相混、經玉人別出心裁、相度形色、雕琢成器、往往成就天然妙趣、爲寰中絕無僅有之奇、名爲巧作、亦足什襲、白玉內尙有帶皮子之一種、此種出和闐、爲水

三品金冠、或蒼玉冠五梁、西京雜記、漢制、王公皆葬以珠襦玉匣、晉書舊事、皇太子
初拜、賜給玉麟符、唐實錄云、高祖始定腰帶之制、諸侯王公將相之玉帶十三胯、而
加兩插尾焉、 國朝祭 太廟及 太廟後殿、並社稷壇正位、皆用玉爵、
大清會典載祭祀之玉、有璧、有琮、有珪、天壇正位、祈穀壇正位、用蒼璧、地壇正位、
用黃琮、社稷壇太社位用白珪、有黃彩、太稷位用青珪、日壇用赤璧、月壇用白璧、是
皆國家用玉之隆規、而昭著旂常者也、

玉色

玉本天生麗質、君子攸珍、品類既稱夫浩繁、色相宜辨其高下、潛確類書曰、玉有五
色、白黃碧三色俱貴、白色如酥者尤貴、餐色油然、及有雪花者次之、黃貴色如栗者、
謂之甘黃、焦黃者次之、碧色青如藍黑者爲上、或有細黑星及色淡者次之、又有赤
玉紅如雞冠、允稱最貴之品、無如此種美玉、世不多覯、綠玉則深綠色者爲佳、淡者
次之、甘青玉其色淡青而帶黃、菜玉非青非綠、色如菜葉最下、墨玉價亦不高、又曰、
赤玉曰璊、曰瓊、瓊又爲瑩澈之義、紫玉曰玭、赤白半曰瑌、碧玉曰瓐、元玉曰瑿、黑玉
曰瑎、黑玉可作鏡曰玖、又王逸玉論載玉之色曰、赤如雞冠、黃如蒸栗、白如截肪、黑
如純漆、謂之玉符、而青玉獨無說焉、今青白者常有、黑者時有、黃赤者絕無、雖禮之
六器、亦不能得其眞者、今儀州出一種石如蒸栗色、彼人謂之栗玉、或云亦黃玉之

鎭圭之等是也、禮神之玉曰器、卽四圭之等是也、服飾玉之飾、謂繅藉在玉若人之
衣服之飾也、又瑑圭璋璧琮、繅皆二采一就以覜聘、四圭有邸以祀天旅上帝、釋曰、
於中央爲璧、謂用一大圭、琢出中央爲璧形、亦肉倍好爲之、四面琢各出一圭、其璧
爲邸、又兩圭有邸以祀地旅四望、祼圭有瓚以肆先王、以祼賓客、註於圭首爲器可
以挹鬯祼祭謂之瓚、又云、圭璧以祀日月星辰、璋邸射以祀山川、以造贈賓客、土圭
以致四時日月、珍圭以徵守、以恤凶荒、牙璋以起軍旅、以治兵守、釋曰、牙璋瑑爲牙、
牙齒兵象也、璧羨以起度、註、璧羨上下一尺、橫徑八寸、不圓之璧以起度量也、又云、
駔圭璋璧琮琥璜之渠眉、疏、璧琮以斂尸、註、渠眉、玉飾之溝瑑也、以組穿六玉溝瑑
之中以斂尸、圭在左、璋在首、琥在右、璜在足、璧在背、琮在腹、蓋取象方明神之也、穀
圭以和難、以聘女、琬圭以治德、以結好、鄭云、琬圭無鋒芒、故治德結好、琰圭以易行、
以除慝、鄭云、琰圭有鋒芒、傷害征伐誅討之象、凡賓客之事共其玉器而奉之、是皆
典瑞之職也、又考工記、玉人、亦專司製玉瑞之職也、禮記玉藻、公侯佩山元玉而朱
組綬、大夫佩水蒼玉而純組綬、世子佩瑜玉而綦組綬、士佩瓀玫而緼組綬、前漢郊
祀志、有司奉瑄玉、註、璧大六寸謂之瑄、漢雋云、武帝元狩元年八月、敕上方製發兵
虎符、王侯用玉、郡國用銅、自甲至癸凡十、左留京師、右以與之、如欲發兵征討、必須
符合方行、章服志、漢制王公玉冠八梁、侯伯駙馬及一品玉冠七梁、二品玉冠六梁、

萬民之寶、皆青玉爲之、曰欽文之寶、曰制馭六師之寶、曰廣運之寶、皆墨玉爲之、其
尊藏　盛京之寶璽、凡玉寶六、曰大清受命之寶、曰皇帝之寶、曰奉天法祖親賢愛
民之寶、皆碧玉爲之、曰皇帝之寶、曰丹符出驗四方、曰敕命之寶、皆青玉爲之、又崇
上　列聖　列后徽號、例用玉寶玉册、尊藏　太廟、皆由內務府恭
製以進、若此者、皆歷代帝王用玉之明徵也、

國家用玉

夫玉之呈功、既式隆於天子、而玉之爲用、自典重於國家、爰考遺編、乃徵文獻、書旅
獒、分寶玉于伯叔之國、周禮、玉府、掌王之金玉、共王之服玉佩玉珠玉、王齊則共食
玉、大喪共含玉、又地官、掌節、掌守邦節而辨其用、以輔王命、守邦國者用玉節、又春
官大宗伯、以玉作六器、以禮天地四方、以蒼璧禮天、以黃琮禮地、以青珪禮東方、以
赤璋禮南方、以白琥禮西方、以元璜禮北方、註、爾雅云、肉倍好謂之璧、琮八方象地
者、圭剡上左右各寸半、半圭曰璋、琥猛象秋嚴也、半璧曰璜、又天府、凡國之玉鎮大
寶器藏焉、若有大祭大喪、則出而陳之、既事藏之、註、玉鎮大寶器、玉瑞玉器之美者、
禘祫及大喪陳之、以華國、書顧命、陳寶赤刀大訓宏璧琬琰在西序、釋曰、宏璧大璧
也、琬琰皆尺二寸者、天府又云、季冬陳玉、以貞來歲之媺惡、註、貞問也、陳玉陳禮神
之玉也、又典瑞、掌玉瑞玉器之藏、辨其名物與用事、設其服飾、註、人執之玉曰瑞、即

德皇后常置之衣箱中、今以賜帝、甚爲寶惜、其後常藏內府、雖其廣不數寸、而温潤
精巧、非人間所有、每京師愆雨、必虔誠祈禱、將有霖霔、逼而視之、若奮麟角、開元遺
事、唐宮中每皇子生、則賜玉錢犀果以爲洗兒之慶、錢文亦皆祝嘏之詞、杜陽雜編、
肅宗賜李輔國香玉辟邪二、其香可聞數百步、輔國嘗置座側、皇朝會典云、中興御
府藏玉寶十有一、一曰鎭國神寶、文曰承天福延萬億永無極、二曰受命寶、文曰受
命于天既壽永昌、二寶封禪用之、三曰天子之寶、答外夷用之、四曰天子信寶、舉大
兵用之、五曰天子行寶、封册用之、六曰皇帝之寶、答鄰國用之、七曰皇帝信寶、賜鄰
國書及物用之、八曰皇帝行寶、降御札用之、所謂八寶也、九曰受命寶、太祖作文曰、
大宋受命之寶、十曰定命寶、徽宗作文曰、範圍天地、幽贊神明、保合太和、萬壽無疆、
十一曰中興受命寶、文曰大宋中興受命之寶、連前凡十一寶也、　國朝　御用
朝帶、色用明黃、龍文金方版四片、其飾、天壇用青金石、地壇用黃玉、日壇用珊瑚、月
壇用白玉、玉輦、玉輅、皆木質髹朱、各飾玉圓版四片、寶璽、藏於交泰殿、凡玉寶二十
有三、曰大清受命之寶、曰天子之寶、曰皇帝尊親之寶、曰皇帝親親之寶、曰皇帝信
寶、曰敬天勤民之寶、皆白玉爲之、曰皇帝奉天之寶、曰皇帝行寶、曰天子行寶、曰敕
命之寶、曰垂訓之寶、曰表章經史之寶、皆碧玉爲之、曰皇帝之寶、曰天子信寶、曰制
誥之寶、曰命德之寶、曰巡狩天下之寶、曰討罪安民之寶、曰敕正萬方之寶、曰敕正

之舞器也、鹵簿記、天子臨軒、百官齊集、以玉鞭三響爲節而班齊矣、穆天子傳、天子之寶璿珠、註、璿珠、玉名、傳國璽考云、秦始皇併六國、得卞和之玉、命工製爲國璽、方四寸、螭虎紐、敕李斯以蟲魚篆書受命于天既壽永昌八字、良工孫壽刻之、以爲傳國璽、子嬰奉其璽降漢高祖、王莽篡漢時、迫太后求出璽、投地刓螭角微玷、其後璽歸光武、董卓亂後、孫堅探井得之、送歸獻帝、尋以禪魏、魏以禪晉、遞入於隋、煬帝遇弑、蕭后攜之北去、貞觀四年、蕭后奉璽歸唐、廢帝自焚、其璽不知所在、漢舊儀云、漢廷國璽凡六、皆白玉螭虎紐、文曰、皇帝行璽、皇帝之璽、皇帝信璽、天子行璽、天子之璽、天子信璽、凡六璽、皇帝行璽、封賜諸侯王書、信璽、發兵徵大臣、天子行璽、策拜外國、事天地鬼神、章服志云、漢制、天子玉冠九梁、輿服志云、秦藍田玉璽、螭獸紐、在六璽之外、漢高祖佩之、後世名爲傳國璽、又高祖登極、郊天玉册、玉色瑩白、斑苔間錯、紅碧丹元之色燦然、凡三頁、文百七十字、漢隸書、書法遒勁、漢書高帝紀、上置酒未央宮前殿、奉玉卮爲太上皇壽、又高祖使張良獻玉斗於范增、唐實錄云、高祖始定腰帶之制、自天子以至諸侯王、公卿將相二品以上、許用玉帶、天子二十四胯、明皇雜錄、天后嘗召諸皇孫、坐于殿上、觀其嬉戲、因出西國所貢玉環釧盃盤、列于前、後縱令爭取、以觀其志、莫不奔競厚有所獲、獨上端坐、略不爲動、后大奇之、撫其背曰、此兒當爲太平天子、因命取玉龍子以賜、玉龍子長數寸、本太宗于晉陽宮所得、文

之玉謂之瑱天子玉瑱、又小雅、鞞琫有珌、註、鞞刀鞘也、琫上飾、珌下飾、天子之戎服也、傳曰、天子玉琫而珧珌、又大雅、左右奉璋、註、半圭曰璋、祭祀之禮、王祼以圭瓚、諸臣助之、亞祼以璋瓚、左右奉之、又受小球大球、註、鄭氏曰小球鎮圭尺有二寸、大球大圭三尺也、皆天子之所執也、書大傳、堯致舜天下、贈以茗華之玉、又舜典、輯五瑞、既月乃日、覲四岳羣牧、班瑞于羣后、註、瑞信也、五瑞五等瑞玉也、即公侯伯子男所執之圭璧也、周禮、天子執冒四寸以朝諸侯、鄭氏註曰、冒玉也、名玉以冒者、言天子以德覆冒天下也、諸侯始受命、天子錫以圭、圭首斜銳、其冒下斜刻、小大長短廣狹如之、諸侯來朝者、天子以刻處冒其圭首、有不同者則辨其僞、故稱瑞也、又巾車、掌王之五路、一曰玉路、又云、王晉大圭、執鎮圭、註、大圭長三尺、天子服之、鎮圭尺有二寸、天子守之、又云、穀圭七寸、天子以聘女、開山圖云、禹王受命治水、元夷蒼水使者授以元圭、上有文字、始知九州之高下、得疏導底勣、功成乃瘞元圭於名山、篆文二字、元玅醅古、世無識者、禮經云、天子佩白玉而元組綬、玉藻云、天子玉藻十二旒、又云、天子搢珽方正於天下也、註、珽謂之大圭、又云、笏天子以球玉、又云、凡君召臣以三節、二節以走、一節以趨、在官不俟屨、在外不俟車、鄭註曰、節以玉爲之、所以明信輔於君命者也、君使使召臣、有二節時、有一節時、合云三節也、隨時緩急、急則二節故走、緩則一節故趨、三禮圖云、天子有六几、玉几其一也、又云、朱干玉戚、天子郊廟

方、又有白玉一段、高六尺、濶五尺、長十七步、以重不可致、金史、大定二十六年皇曾孫生、宴於慶和殿、賜曾孫玉山子兔兒垂頭一副、章宗進玉雙駝鎮紙、玉琵琶撥、玉鳳鉤骨覩等物、逮降於今、大而瓶盤甕釜、小而瓊珮簪環、佐觴政則洗爵奠斝、通聘問則錢璧珪璋、尊罍開北海之尊、壺傾三雅、壽佛祝南山之壽、屏列八仙、如意鏡臺、爲奩妝之佳品、釵釧鈿珥、乃首飾之殊觀、文房焚百合之香、爐瓶三事、繡閣列四時之景、盆卉雙榮、玉梳櫛髮、晨興理厥烏雲、玉枕橫陳、午倦資其清夢、隔腕爲臨池之用、壓舌乃殉歛所需、脂盒粉盝、佳人之面似桃花、筆筒墨床、學士之窻排文陣、輪螺繖蓋花罐魚腸、爲仙室吉祥之八寶、綻裂石榴蟠桃佛手、乃借用祝嘏之三多、玉連環表不斷之情、玉印信示真誠之據、素珠記宣佛號、鎮紙亦列文房、障面之冰紈有墜、垂胸之玉鎖無簣、以玉綴嬰兒之脅、任厥吮咂、以玉殉亡者之身、希其不朽、他如搗藥之杵臼、較射之搬指、吸烟之具玉嘴稱良、噉飯之方玉箸爲便、玉圈束指、戒酒色之沉酣、玉管餐霞、嗜西洋之鴉片、蓋自天子以至庶人、冠昏喪祭、日用服食、無所往而不用玉也、

天子用玉

古之君子以玉比德、湼而不淄、磨而不磷、或澤而瑩、或温而栗、故三代至今、舉凡宗廟重器、朝廷大寶、咸以美玉製之、而天子所用尤足述焉、詩衛風、充耳琇瑩、傳、充耳

光臺、臺上撞碧玉之鐘、又玉者功成治定、告成於天、刻石紀號、封以金泥玉檢、又未
央宮以玉爲戶、三輔黃圖云、董偃嘗卧於延清之室、以畫石爲床、以紫玉爲盤如屈
龍、皆用雜寶飾之、又以玉晶爲盤、蓄冰於膝前、玉晶與冰相潔、侍者謂冰無盤必融
溼席、乃拂去盤墜、冰玉俱碎、玉晶乃于闐國所貢也、武帝以之賜偃、魏書、文帝有劒
一枚、明珠標首、藍玉飾靶、用給左右以除妖氛、胡琮別傳、吳時掘地得銅匣、以琉璃
爲蓋、布雲母於其上、開之、得白玉如意、大帝以問琮、對曰、秦始皇以金陵有天子氣、
處處埋寶物以壓王氣、異苑曰、晉王騰鎭鄴、遊常山時、天大雪、平地數尺、營門前方
尋丈、融液不積、因掘之、得玉馬高尺許、又宏農楊子陽、聞土中有聲、掘得玉豘、長可
尺餘、涼州記、咸寧二年、有盜發張浚墓、得白玉尊玉簫玉笛各一事、拾遺記曰、晉太
始初、頻斯國人來朝、以五色玉爲衣、如今之鎧、又勃鞮國獻黑玉之環、色如漆、又晉
王衍、以玉爲麈尾之柄、又因墀國在西域之北、晉武帝時、獻玉錢千緡、其形如環、環
重十兩、上刻天壽永吉四字、南史、梁天監九年、于闐國遣使獻方物、大同七年、又獻
其國所刻之玉佛、唐六典、祀天地之神用石磬、宗廟及殿廷用玉磬、唐書、高宗乾封
初、封泰山玉策、以玉爲簡、刻以金文、藏以玉匱、杜陽雜編、唐元載紫龍鬚拂、刻紅玉
以爲環紐、宋史、天聖三年、于闐國遣使來朝、貢玉鞍轡、白玉帶、續文獻通考、元丞相
伯顏、嘗至于闐國、鑿井得一玉佛、高三四尺、色如截肪、照之皆見筋骨脈絡、即貢上

成器、非自今日始也、書、在璿璣玉衡以齊七政、又金縢、周公立焉植璧秉珪、又顧命、相被冕服憑玉几、詩國風、君子偕老、副笄六珈、註、以玉加於笄而爲飾也、又、投我以木瓜、報之以瓊琚、投我以木桃、報之以瓊瑤、投我以木李、報之以瓊玖、註、瓊玉之美者、琚珮玉名、瑤玖皆美玉也、又毳衣如璊、註、玉赤色、又知子之來之、雜佩以贈之、註、雜佩左右佩玉也、又小雅、載弄之璋、周禮天官、大朝覲會同、贊玉幣玉獻玉几玉爵、又玉府、若合諸侯、則共珠敦玉槃、又春官、凡祀大神、涖玉鬯奉玉齍、註、鬯酒器、齍黍稷器也、又秋官小行人、成六瑞、王用鎭圭、公用桓圭、侯用信圭、伯用躬圭、子用穀璧、男用蒲璧、合六幣、圭以馬、璋以皮、璧以帛、琮以錦、琥以繡、璜以黼、此六物者以合諸侯之好故、禮明堂位、灌用玉瓚大圭、薦用玉豆雕篹、爵用玉琖、又夏后氏之四璉六瑚、註、瑚璉宗廟盛黍稷器也、左傳、昭公十七年、鄭裨竈曰、若我用瓘斚玉瓚鄭必不火、註、瓘圭也、又昭公二十九年、公賜公衍羔裘、使獻龍輔於齊侯、遂入羔裘、齊侯喜、與之陽穀、註、龍輔玉名、陽穀齊邑也、爾雅釋器、今之角弓以玉飾兩頭、曰珪、又圭大尺二寸謂之玠、璋大八寸謂之琡、璧大六寸謂之宣、肉倍好謂之璧、好倍肉謂之瑗、肉好若一謂之環、西京雜記、秦關咸陽、曾有玉笛、長二尺三寸、上列二十六孔、及高祖初入咸陽、周行庫藏、見而吹之、則山林車馬隱嶙相次、吹息不復見、名之曰昭華之琯、漢書文帝紀、十六年秋九月、得一玉杯、刻有人主延年四字、又武帝紀、上起騰

言、天寶遺事、楊貴妃含玉嚥津以解肺渴、酉陽雜俎、馬常侍嘗寶一玉精椀、迴非常玉可比、雖當夏月而蠅不能近、以之盛水、經月不腐不耗、或有目痛、合之立愈、夷堅志云、唐宣宗朝有十二玉碁子、上有十二時、用盆蓄水、以碁子置於水中、逐時自行浮出、不差晷刻、之數者、雖屬可寶、爲世罕見、然亦不過供人玩賞、所寶猶小也、若史記所云、趙惠文王得楚和氏璧、秦昭王請以十五城易之、左傳云、晉執魏侯歸之京師、王使醫衍酖魏侯、甯俞貨醫使薄其酖、遂不死、魯公爲之納玉於王與晉侯皆十瑴、王許之、乃釋魏侯、註、雙玉曰瑴、又晉侯伐齊、將濟河、獻子以朱絲繫玉二瑴而禱、沉玉而濟、此則關於君國性命、豈若匹夫懷璧而區區是寶也哉、又有以人力製造而巧奪天工者、漢武故事云、上起神屋前庭植玉樹、以珊瑚爲枝、碧玉爲葉、華子青赤、以珠玉爲之、空其中如小鈴、鎗鎗有聲、是皆以游目悅心而取貴者、至服食之中亦有可寶、河圖玉版云、少室之山、有白玉膏、服之成仙、十洲記云、瀛洲有玉膏如酒、名曰玉醴、飲數升輒醉、令人長生、抱朴子云、生玉之山、有玉膏流出、鮮明如水精、以無心草木和之、須臾成水、服一升得千歲、藏器曰、今玉石間水、飲之亦長生潤澤、是則餐玉便可成仙、亦取貴之無上上乘矣、

玉器

禮記曰、玉不琢不成器、孟子曰、今有璞玉於此、雖萬鎰、必使玉人雕琢之、然則因玉

子曰、昔君子比德於玉焉、温潤而澤仁也、縝密以栗知也、廉而不劌義也、垂之如隧
禮也、叩之其聲清越以長其終詘焉樂也、瑕不掩瑜瑜不掩瑕忠也、孚尹旁達信也、
氣如白虹天也、精神見於山川地也、圭璋特達德也、天下莫不貴者道也、詩云、言念
君子温其如玉、故君子貴之也、五音集韻、烈火燒之不熱者眞玉也、說文、璠璵魯之
寶玉也、孔子曰、美哉璠璵、遠而望之奐若也、近而視之瑟若也、一則理勝、一則孚勝、
稗官、火玉色赤可烹鼎、暖玉可辟寒、寒玉可辟暑、香玉有香、軟玉質柔、觀日玉洞見
日中宮闕、此皆希世之寶也、前漢王莽傳、美玉可滅瘢、西京雜記、咸陽宮有青玉鐙
五枚、高七尺五寸、作蟠螭以口含鐙、鐙然鱗甲皆動、煥爛盈室、杜陽雜編云、唐時日
本國進暖玉紋楸枰、冬月圍之不寒、以爲至寶、又唐代宗幸興慶宮、複壁間得寶匣、
匣中獲玉鞭、鞭末有文曰軟玉鞭、卽天寶中異國所獻、屈之則頭尾相就、舒之則勁
直如繩、雖鍜所不傷缺、上歎爲異物、遂命聯蟬繡爲囊、碧玉爲鞘、又日本東三萬里
有集莫島、島上有凝霞臺、臺上有手談池、池中出玉碁子、不由製度、自然黑白分明、
冬月則温、夏月則冷、謂之冷暖玉、更產楸玉、狀如楸木、琢之爲碁局、光潔如鑑、又順
宗時西域進美玉二枚、一圓一方、徑各五寸、光彩可鑑毛髮、時伊祈元解方坐於上
前、熟視之曰、一龍玉、一虎玉、蓋圓者龍也、生於水中、爲龍所寶、投之水中、必有虹霓
出焉、方者虎也、生於巖谷、爲虎所寶、以虎毛拂之、卽紫光迸逸、而百獸懾伏、上異其

非子云、楚人卞和得璞玉於楚山、獻厲王、王使人相之曰石也、王以爲誑、刖其右足、
武王卽位、和又獻之、復相曰石也、又刖其左足、迨文王卽位、和抱璞哭於楚山之下、
三日三夜泣盡繼之以血、王使玉人理其璞而得其寶焉、於以知美玉皆出於璞、能
辨其璞、斯爲眞知玉矣、且璞之爲物、亦足列入藥品、益人精神、療人疾病、宏景曰玉
屑是以玉爲屑、非別一物也、仙經云、服玉有搗如米粒以苦酒消化令如泥、亦有合
爲槳者、凡服玉皆不得用已成器物、及塚中玉璞、恭曰餌玉當以消作水者爲佳、屑
如麻豆服者、取其精潤臟腑、滓穢當完出也、又有爲粉服者、卽使人淋壅、屑如麻豆
其義殊深、論其氣味、則甘平無毒、能除胃中熱、喘息煩滿、止渴、屑如麻豆服之、愈久
則輕身長年、潤心肺、助聲喉、滋毛髮、且復滋養五臟、宜共金銀麥門冬等同煎服、愈
爲有益、他如玉泉、玉槳、瓊槳、諸品皆用未雕琢之玉、以法消化爲水也、以上諸說見
之本草、而取材適用、均係未治之璞、然則太璞之足、尙成器之玉、轉覺畧遜一籌矣、

玉貴

玉之爲物、堅剛而有潤、精密而生輝、爲兩間拔萃之材、擅萬有無雙之貴、詩小雅他
山之石可以攻玉、註、程子曰、玉之温潤、天下之至美也、石之麤糲、天下之至惡也、然
兩玉相磨、不可以成器、以石磨之、然後玉之爲器得以成焉、周禮、玉方寸重七兩、石
方寸重六兩、禮記、子貢問曰、敢問君子貴玉而賤珉何也、爲玉之寡而珉之多耶、孔

點、迨回子出水、官則按點數索其玉子、去葉爾羌二百三十里、有山曰米爾台搭班、徧山皆玉、五色不同、然石夾玉玉夾石、欲求純玉無瑕大至千萬觔者、則在絕高峻峰之上、人不能到、惟彼處土產犛牛慣於登陟、回子攜具乘牛、攀援鎚鑿、任其自落而收取焉、俗謂礤子石、又名山石、每歲春秋二季、葉爾羌貢玉七八千觔至萬觔不等、迤南七百里爲和闐回城、土田平廣、沃野千里、皆出玉子、較之葉爾羌爲尤多、今則陜之西安、粵之桂林、豫之許州、與夫新疆之莎車和闐等處、均爲產玉之區、碧玉俗呼爲雲南玉、惟雲南不聞產玉、蓋碧玉實緬甸所出、販玉人出入內地、皆由滇省經過、遂相率以雲南二字冠諸玉上、用以別其品類云、

璞玉

璞也者、未治之玉也、既獲之後、雕琢未施、挺自有之天姿、抱本來之純素、不假修飾、自成奇珍、書顧命、大玉夷玉天球河圖在東序、釋曰、大玉華山之球、夷玉東北之璞、天球雍州所貢之玉色如天、三者皆璞、未見琢治、故不以器名之、符瑞圖云、玉瑛仁寶、不斲自成、光若白華、漢文帝時渭陽玉瑛見、一云、五常修則玉瑛見、韻會、凡玉之生、以及其成、有榮有英、有華有實、猶草木也、瑩卽榮也、謂玉之始生如草木之榮也、英謂一玉之中最美者、如草木之英、華謂玉之方成、如草木之華、實謂玉之旣成、如草木之實、皆可用之玉也、相玉書、玉大六寸光自照、謂之璭、道德經、璞散則爲器、韓

里、二曰綠玉河、在城西二十里、三曰烏玉河、在綠玉河之西七里、其源雖一、而其玉隨地而變、故其色不同、每歲五六月大水暴漲、則玉隨流而至、玉之多寡、由水之大小、七八月水退、乃可取、彼人謂之撈玉、其國中有禁、器用服食、往往用玉、而中國所有之玉、亦自彼來、又有種玉之田、考之搜神記云、雍伯父母終、葬於無終山、山無水、雍伯作義漿坂頭、有人就飲、出石子一升授之、謂之曰種之、卽生美玉、後果然、今之直隸玉田縣屬、亦有種玉之田、至產玉之山、則非一處、爾雅釋地、東方之美者、有醫無閭之珣玗琪焉、註醫無閭山名、今在遼東、珣玗琪玉屬、又西方之美者、有霍山之多珠玉焉、註霍山、今在平陽永安縣、又西北之美者、有崑崙虛之璆琳琅玕焉、註璆琳美玉名、琅玕、狀如珠也、崑崙山名、虛山下基也、他如周有藍田、楚有和氏、宋有結綠、晉有垂棘、此皆各具其國之貴品、而他處之玉不能少同者也、此外則有葉爾羌之玉子、按西域聞見錄載、葉爾羌者、回疆一大城也、其地有河、產玉石子、大者如盤如斗、小者如拳如栗、有重至三四百觔者、其色亦各不同、如雪之白、翠之青、蠟之黃、丹之赤、墨之黑者、皆上品、其尤難得者、則有一種羊脂朱斑、一種碧如波斯菜而金片透溼者、則愈美、河底大小石錯落平鋪、玉子雜生其間、採之之法、遠岸官一員守之、近河岸營官一員守之、派熟練回子或三十人一行、或二十人一行、截河並肩赤腳踏石而步、遇有玉子、回子卽腳踏知之、鞠躬拾起、岸上兵擊鑼一棒、官卽過硃一

華夏處士大興唐榮祚錫五甫

產玉

乾坤之靈秀、或鬱爲休徵、山水之精英、每凝爲寶玉、故凡產玉之區、多在山川之內、歷稽載籍、可畧言焉、書禹貢揚州之域、厥貢瑤琨篠簜、傳瑤琨皆美玉也、又梁州之域、厥貢璆鐵銀鏤砮磬、註璆玉磬也、又雍州之域、厥貢惟球琳琅玕、註球琳美玉也、可爲圭璋之用、周禮夏官正西曰雍州、其利玉石、禮記云、石韞玉則氣如白虹、精神見於山川也、博物志云、山有穀者生玉、淮南子水圓折者有珠、方折者有玉、玉鏡圖云、二月山中草木生光下垂者有玉、玉之精如美女、玉書云、玉有山元文水蒼文、生於山而木潤、產於水而流芳、藏於璞而文采露於外、觀此諸說、則玉有山產水產二種、中國之玉多在山、而于闐之玉則在河也、本草宏景曰、好玉出藍田、及南陽日南、廬容水中、外國于闐疏勒諸處皆善、潔白如猪膏、叩之鳴者是眞也、其比類者甚多相似、宜精别之、異物志云、玉出崑崙、别寶經云、凡石韞玉、但將石映鐙看之、內有紅光明如初出日、便知有玉也、頌曰、今藍田南陽日南、不聞有玉、惟于闐國出之、後晉天福中、鴻臚卿張匡鄴使于闐、作行程記、載其國采玉之地曰玉河、在于闐城外、其源出崑山、西流一千三百里、至于闐牛頭山、乃疏爲三河、一曰白玉河、在城東三十

光緒庚寅

玉說

古腴軒主人題

古腴軒印

YÜ TSO T'OU

ILLUSTRATIONS OF THE MODERN MANUFACTURE OF JADE

WITH INTRODUCTION AND TABLE OF CONTENTS

BY

LI SHIH-CH'ÜAN

Styled "Chêng-yuan"

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PREFACE

The "Classic Book of Rites" says: "If Jade be not carved it cannot make a vessel." This means that jade, which is brought from the mountains or rivers a crude, formless mass, requires the skill of clever workmen to select the best part and carve and polish it properly, before it can be made into a finished vessel.

Doctor Bushell, an Englishman, who has spent over twenty years of his life in the Central Kingdom,[1] being naturally fond of ancient works of art, has gathered together a large collection of specimens of Chinese work in porcelain, bronze, and jade, which, during moments of leisure from official work, he takes much interest in studying. Of the different kinds of jade he has picked out some of the choicest and most beautiful of the pieces,[2] and offered them to the photographer, who has made a series of illustrations. He has also invited the learned T'ang Jung-tso to write a "Discourse on Jade," to be printed and published for the benefit of those interested in the subject. Only, fearing that, in the absence of plates to illustrate the art of carving and polishing jade, it could hardly be found that the description was altogether clear, he has instructed me to go personally to see the various processes of carving and polishing, and to make pictures of them, in the hope that those who may consult the book may be more thoroughly satisfied.

This work of Doctor Bushell, although only a leisure occupation, will yet fill a small unknown gap in the exact knowledge of handicraft work.

This Preface was written in the cyclical year *kêng yin* of the reign of Kuang Hsü, in the last ten days of the fourth month, at Yen Tu (Peking), by the artist Li Shih-ch'üan, styled Chêng-yuan.[3]

[1] The name "China" is unknown to the natives of that country. Their name for the country is *Chung Kwoh*, "Central (or Middle) Kingdom."

[2] The artist is wrong here, my own Collection being only of porcelain and bronze. The illustrations he refers to are those of Mr. Bishop's beautiful series of jades, some photographs of which I had once shown to him.— S. W. B.

[3] The Preface is stamped at foot in vermilion with two seals, the first inscribed with the author's personal name, "Li Shih-ch'üan," the second with his literary, or artistic, name, "Chêng-yuan."

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一 搗沙圖 二 研沙圖
三 開玉圖
四 扎玉圖

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五 衝碢圖
六 磨碢圖
七 掐堂圖

玉作圖序

禮云玉不琢不成器是則玉產於山水間者完璞混如必得良工量材適用依法琢磨方能以成其器也今英國醫士卜君在中華歷二十餘載性愛古玩凡中華之磁銅玉器採買甚夥公餘之暇隨心撿閱將所買上上極好各品玉器付照畫作圖板復請榮祚唐先生選作玉說刊刻成書以公諸同好惟惜無人工琢磨之圖未免閱書者聊有不慊之意遂囑余歷觀玉作琢磨各式繪以成畣想閱書者將欣然而有喜色也卜君之舉雖屬閒情然於格物致知之學不無小補云爾是為序

旹

光緒十七年歲次辛卯新秋上浣　燕都居士石泉李澄淵畫并序

目録
八 上花圖
九 打鑽圖
十 透花圖

目録
十一 打眼圖
十二 木碢圖
十三 皮碢圖

ILLUSTRATIONS OF
THE MANUFACTURE OF JADE

I. POUNDING THE SAND

THERE are many kinds of tools used in working jade, but they do the work not by their own strength, but by the help of the stone sand. I am informed that the black, red, and yellow sands employed all come from Huo-lu Hsien, in the province of Chih-li, and that some is also brought from the province of Yunnan. It comes in pieces like the small anthracite coal used by blacksmiths, and requires to be pounded with pestle and mortar to the size of broken rice. This is then passed through a very fine sieve, washed to separate impurities, and then, when water is added, it is fit for use.

II. GRINDING THE SAND

THE yellow sand used for the polishing wheel requires to be ground down very finely and evenly, after which it is washed and mixed with water, ready for use.

N. B. These two operations are combined in the first picture, and the tubs below contain the black sand, characterized as very hard; the red sand, as a little softer; and the yellow sand, as still softer than the red; the tub on the left being filled with a fourth kind, called *pao liao*, "precious-stone dust," for use on the leather wheel, which gives the final polish to the jade.

III. SAWING OPEN THE CRUDE JADE

THE tool used is a two-handled steel saw, kept moist with black sand mixed with water. If it be a very large, heavy block of jade, it is sawn open, as illustrated in the picture. If the block of jade be only 20 or 30 catties in weight, it is suspended on a steelyard, and sawn open with a large plate-saw 20 inches in diameter. The jade is found in nature generally enveloped in stone, and to get at the jade this skin must first be stripped off, just as a fruit is peeled to get at the kernel. This is the first process in working jade.

一

搗沙圖說　攻玉器具雖多大都不能施其器本性之能力不過助石沙之能力耳傳云黑紅黃等石沙產於直隸獲鹿縣雲南等處亦有之形似甚碎砟子必須用

杵臼搗碎如米糝再以極細篩子篩之然後量其沙之粗細漂去其漿將淨沙浸水以適用

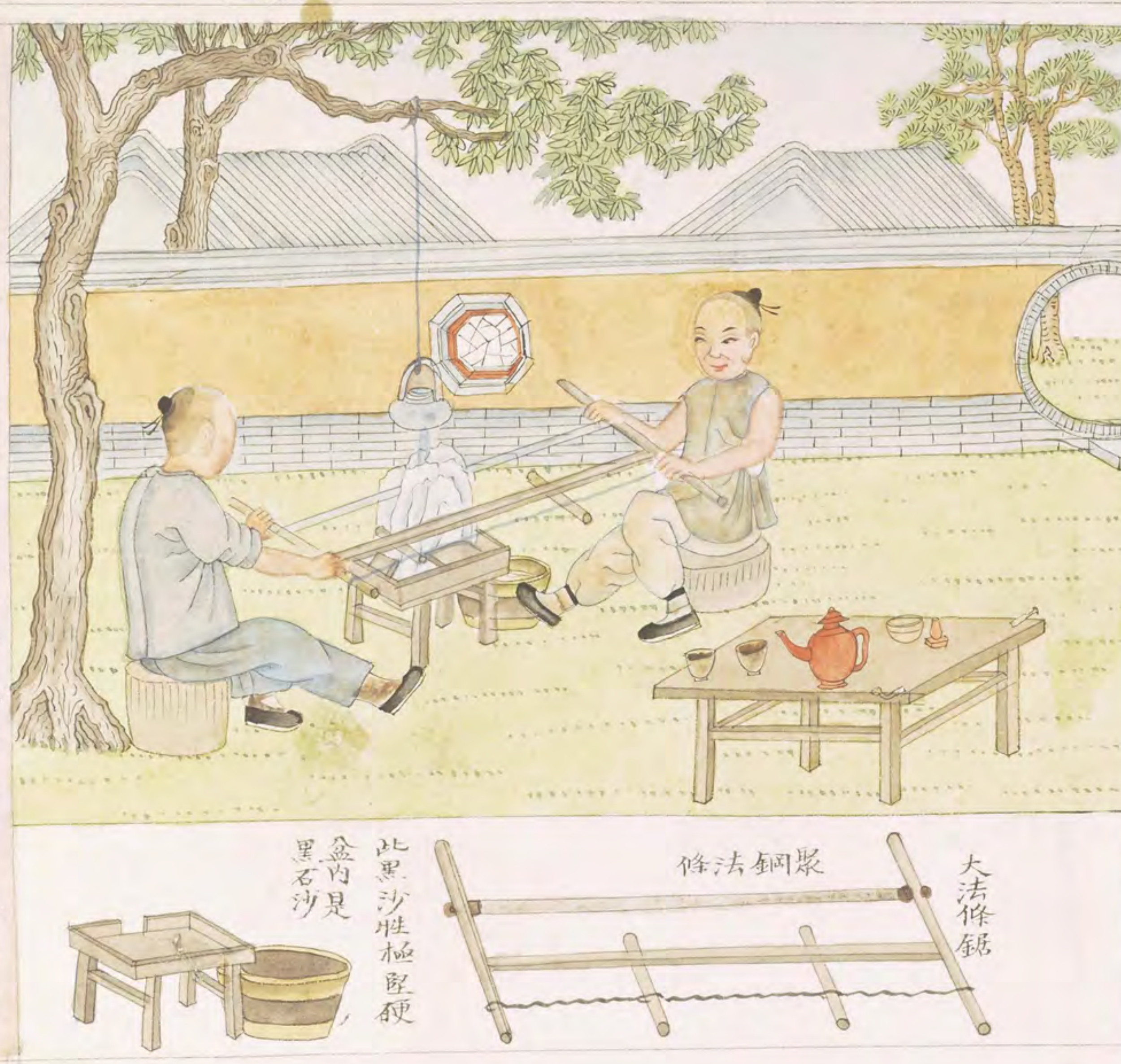
二

研漿圖說　磨光宜研極細膩黃沙去漿浸水以適用

三

開玉圖說

器用聚鋼條及浸水黑石沙凡玉體極重即宜用此圖內所畫之爲以開之　至若玉重二三十斤則以天秤吊



之再用尺六見圖大扎碣開之論玉之產于山水其原體皆有石皮今欲用其玉必先去皮若剝菓皮而取其仁也故云開玉此攻玉第一工也

IV. THE SLICING SAW

THIS saw is mounted on a wooden axle, and consists of a round plate of steel with an edge as sharp as that of a knife. It is called the slicing saw, and is moistened with red sand mixed with water to saw up the jade, from which the envelope has been stripped, into square or oblong slabs, of a size corresponding to the object to be made, ready to be fashioned by the shaping wheel. If the piece of jade be large and heavy, it is suspended on the end of a steelyard, as in the picture; if it be small and light, it is held in the hand, the steelyard not being required.

N. B. The plate-saw, the axle and the treadles, with which it is worked, are figured in detail below, as well as an iron hammer and block for keeping the plate hammered, in shape. Saws of different sizes are placed ready on the table, and wooden guards to protect the workmen hang on the wall.

V. THE SHAPING WHEELS

THESE wheels are rings of steel from half an inch down to two or three lines in thickness. The axis of the ring is mounted with a thick slab of bamboo, with a depression in the centre, into which the wooden axle-rod is stuck with red glue. This wheel is used to remove the sharp edges and corners from the square or oblong piece of jade, hence its name of shaping wheel. When the edges have been thus removed, the object is shaped, but the jade is still rough and uneven, so that it requires the grinding wheel to smooth it, and the wooden wheel, glue wheel, and leather wheel to give it a final bright polish.

四 扎碢圖說

碢用木作軸用鋼作圓盤邊甚薄似刀名之曰扎碢用浸水紅沙將去淨石皮原玉截成方塊或方條再料其材以

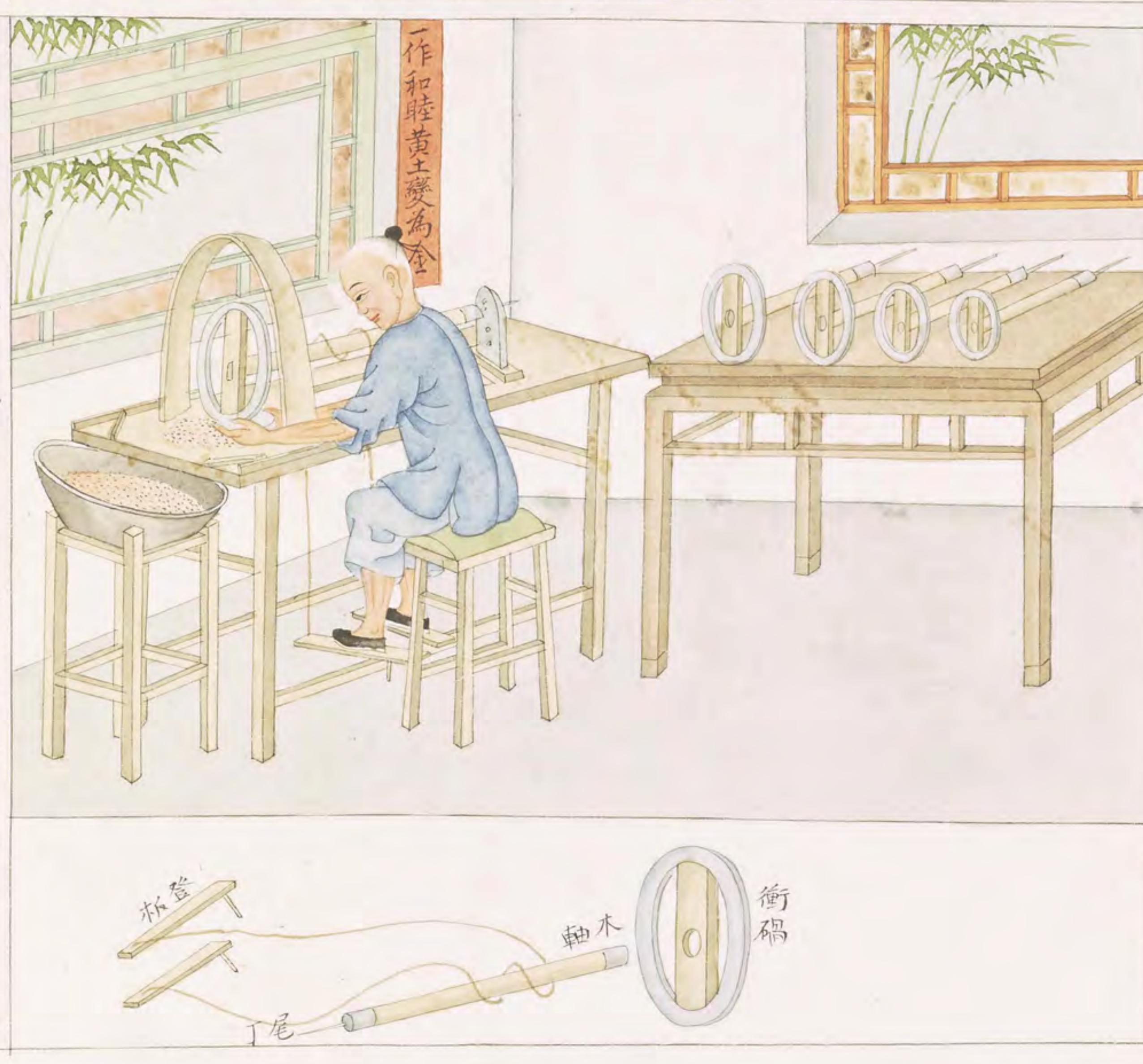
為器用衝碢磨之以成其器之胎形

若大玉料體重則以天秤吊之如小而輕則以手托之不用

天秤

五 衝碢圖說

碢用四五分或二三分厚鋼圈圈內橫以厚竹板再以紫膠接在木軸頭上用浸水淨紅沙以衝削其方條玉之棱角



故名衝碢玉之棱角既去器形既成玉體膚上尚有小坳

沙痕則宜磨碢以磨之木碢膠碢皮碢以光亮之

VI. THE GRINDING WHEELS

The grinding wheels are steel plates two or three lines in thickness, turned on a wooden axle. These grinding wheels are of six or seven different sizes. They are used to grind the piece that has been fashioned by the shaping wheel, till the surface is uniformly smooth. When this work is finished the piece is ready to have ornamental designs carved upon it, to be bored with the diamond, or to be hollowed out or pierced, whenever such work is required.

VII. HOLLOWING THE INTERIOR

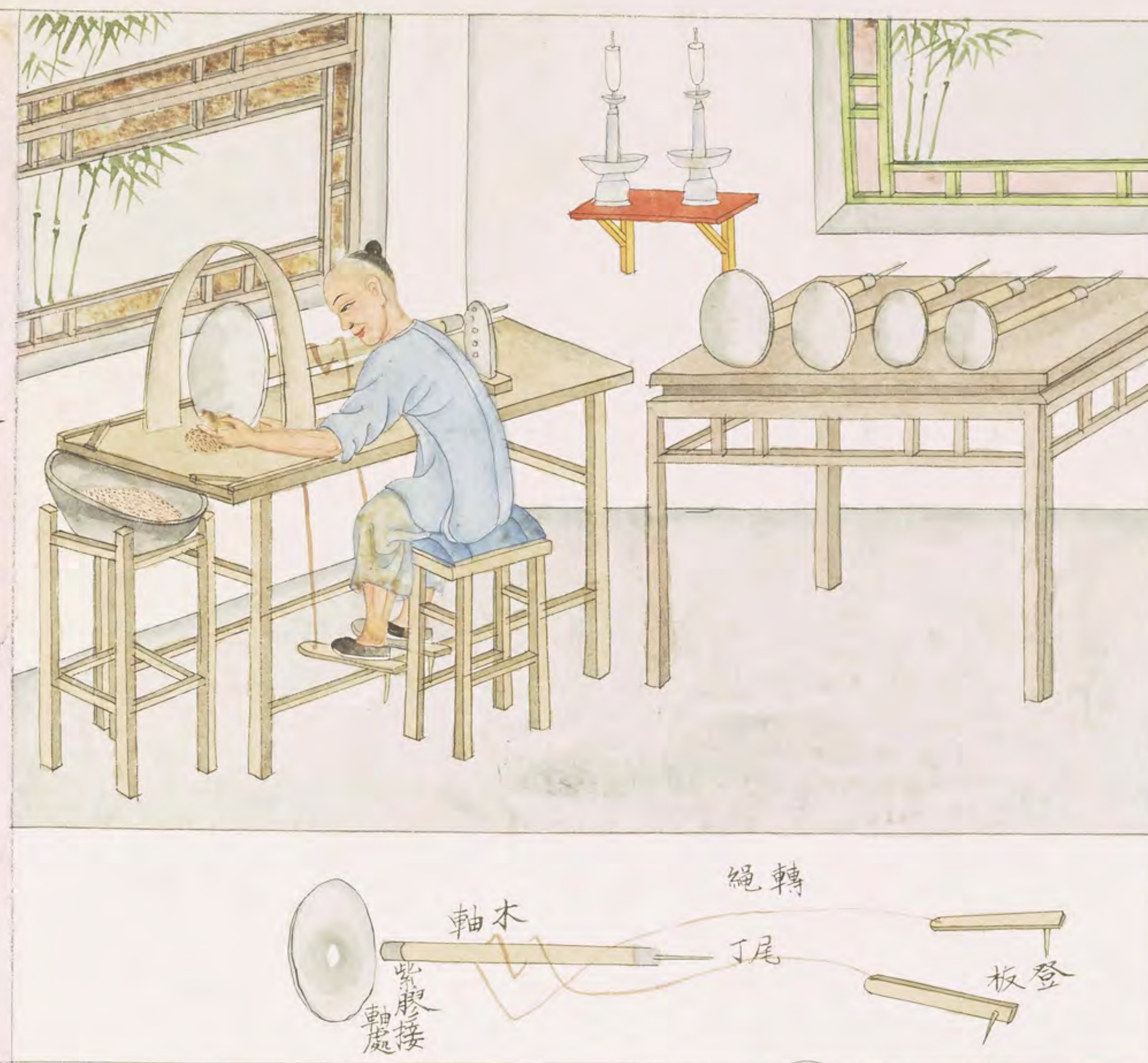
By hollowing the interior is meant "removing the core." Whenever a hollow space has to be left inside the jade object, it must be first bored with the round steel cylindrical borer, which, after the boring is finished, leaves a round core inside. This core has to be dug out with a steel chisel struck by a small hammer. If the mouth of the jade object is to be left small and the chamber larger, flat steel gimlets, like corkscrews, are used to hollow out still more the interior of the piece.

N. B. The borer is mounted, as figured below, on an iron rod, and is channelled twice or three times, to allow the sand to get in. The gimlets are fixed into a hollow in the end of a similar iron rod. The revolving strap attached to treadles is made of leather.

六

磨碢圖說

磨碢用二三分厚鋼盤木軸碢形大小不同約有六七等
既衡之後則宜磨之使玉體細膩磨工既畢宜上花宜



打鑽宜掏堂宜打眼再容施其工

七

掏堂圖說

掏堂者去其中而空之之謂也凡玉器之宜有空堂者
應先鋼捲筒以掏其堂工完玉之中心必留玉梃一根則

遂用小鎚擊鋼鏨以振截之此玉作內頭等最巧之技也
至若玉器口小而堂宜大者則再用扁錐頭有彎者就浸
水細石沙以掏其堂

VIII. CARVING ORNAMENTAL DESIGNS

WHEN the jade has to be decorated with ornamental designs the tools used are of two kinds. The first are small round plates of steel, with sharp edges like knives, called nails (*ting-tzŭ*) because they are somewhat like round-headed nails in shape. The others are small steel plates with thicker edges, called *ya t'o*. These tools are made of many different sizes and shapes, according to the fancy of the workman and the nature of the work required. All jade objects, of square or round form, of large or small size, which are to be ornamented outside with different designs, must have the patterns carved with these tools.

N. B. Some of these small plates are figured below, with the iron rod on which they are mounted, a little hammer to drive them into the hollow end of the rod, and another tiny hammer to straighten the plate of the "nails."

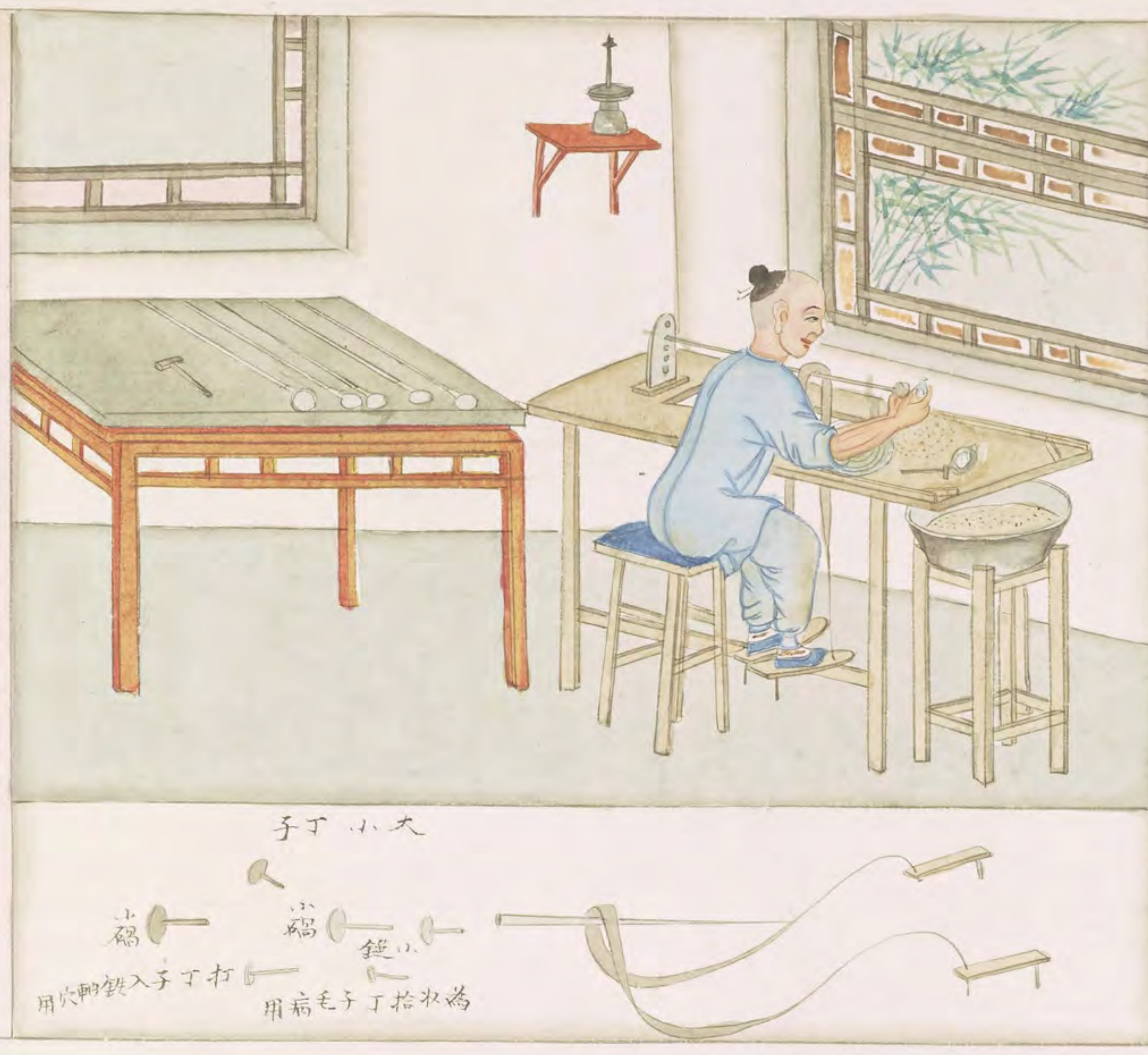
IX. THE DIAMOND BORER

WHEN the jade object has to be carved in openwork (*à jour*), holes must first be pierced with the diamond, following the pattern of the design. This work is called diamond-boring, and only after it is done can the wire bow-saw be introduced and worked round the outline of the pattern. The pieces carved in openwork and decorated with ornamental designs have still to be polished to finish them off.

N. B. The lever which presses down the diamond is figured below, a weight being suspended to the arm by a string which passes through a round hole in the middle of the table, while a small cup is fixed underneath the end of the arm to hold the rod in which the diamond is fixed, which the workman turns, with the bow in his right hand, holding the piece of jade with his left.

八上花圖說

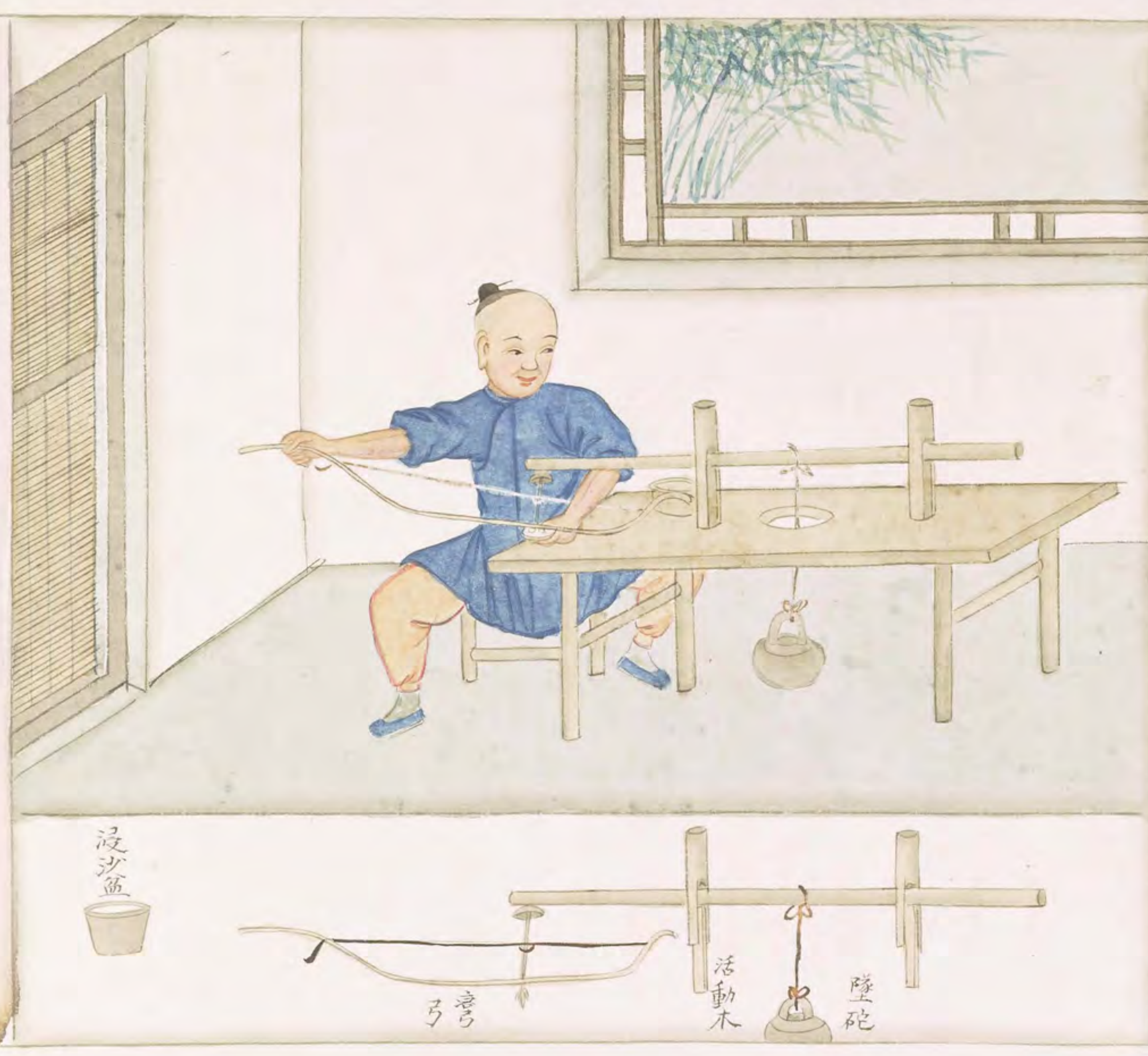
按玉作上花具皆用小圓鋼盤之邊甚簿似刀名之曰丁
子全形似圓帽丁子故名之或用小鋼碣名為軋碣此等具



可以隨意改作大小以方便適用為度
凡玉器無論大小方圓外面應有花樣者皆用此等具
磨衎以上花

九
打鑽圖說

是玉器宜作透花者則先用金鋼鑽打透花眼者為打
鑽然後再以彎弓鋸就細石沙順花以搜之透花工畢再施



上花磨亮之工則器成

X. OPENWORK CARVING

When a slab of jade has to be carved in openwork it must be pierced with round holes by the diamond borer and afterward sawn with a steel wire stretched on a bow. When this is used, one end of the wire is first loosened, so that the wire may be passed through one of the holes, after which it is fastened again to the end of the bow. It is then moistened with sand and water and the jade sawn out, following the outline of the pattern. An upright piece of wood is fixed in the table, or a horizontal piece nailed on, with a vise attached, to grasp the jade object firmly.

N. B. The apparatus is figured in more detailed form below, with bow both strung and unstrung.

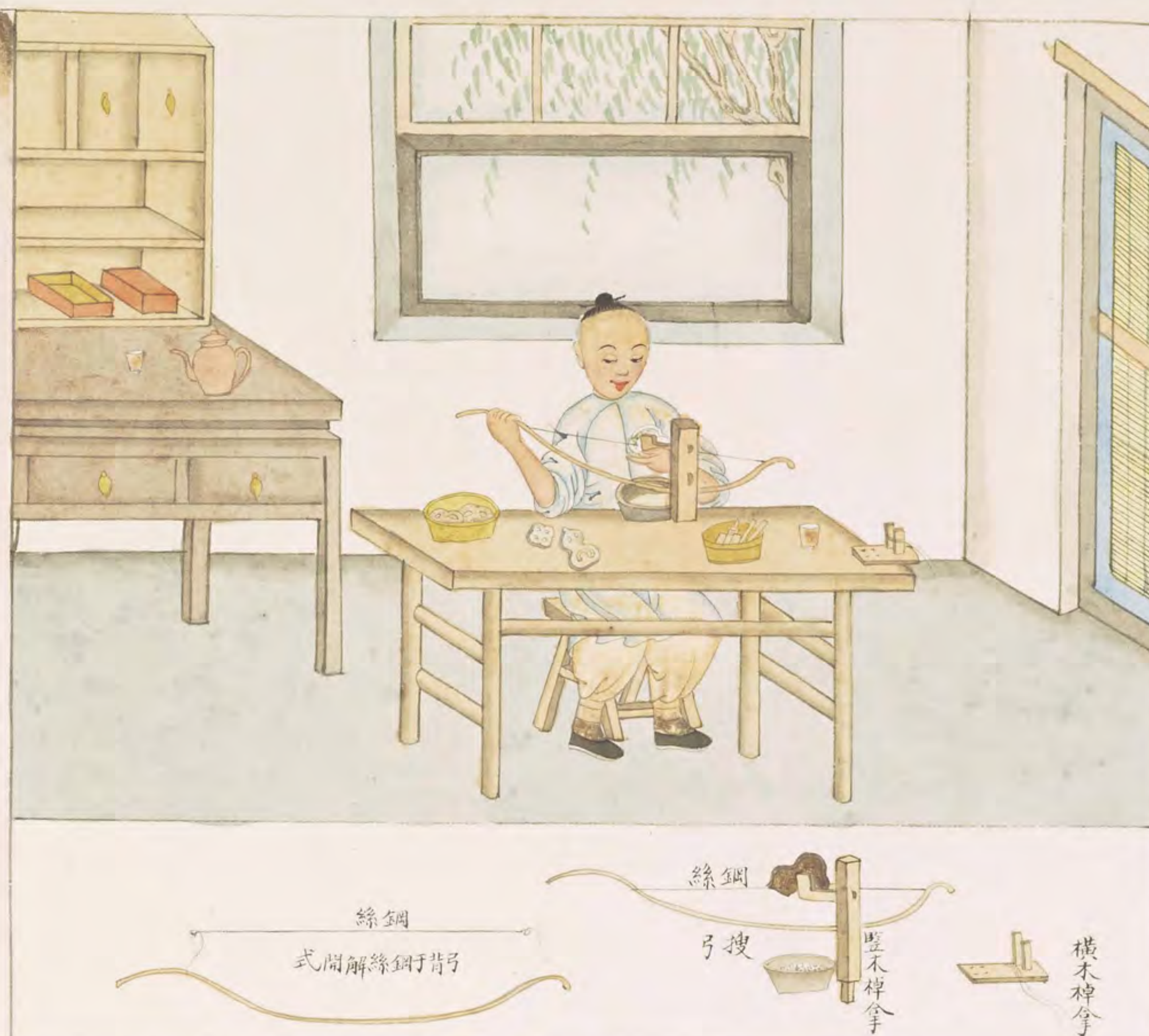
XI. PIERCING HOLES

Small objects, such as snuff-bottles, thumb-rings, mouthpieces of tobacco-pipes, and the like, which cannot be held in the hand, are placed in a large bamboo cylinder about nine inches high, filled with clear water, on which float pieces of wood pierced with holes or hollowed into nests corresponding in size to that of the jade articles. The jade having been fixed in one of these cavities, the left hand of the workman is left free to press the diamond borer with a little iron cup held in the palm, while his right hand wields the bow which pierces the holes.

十 透花圖

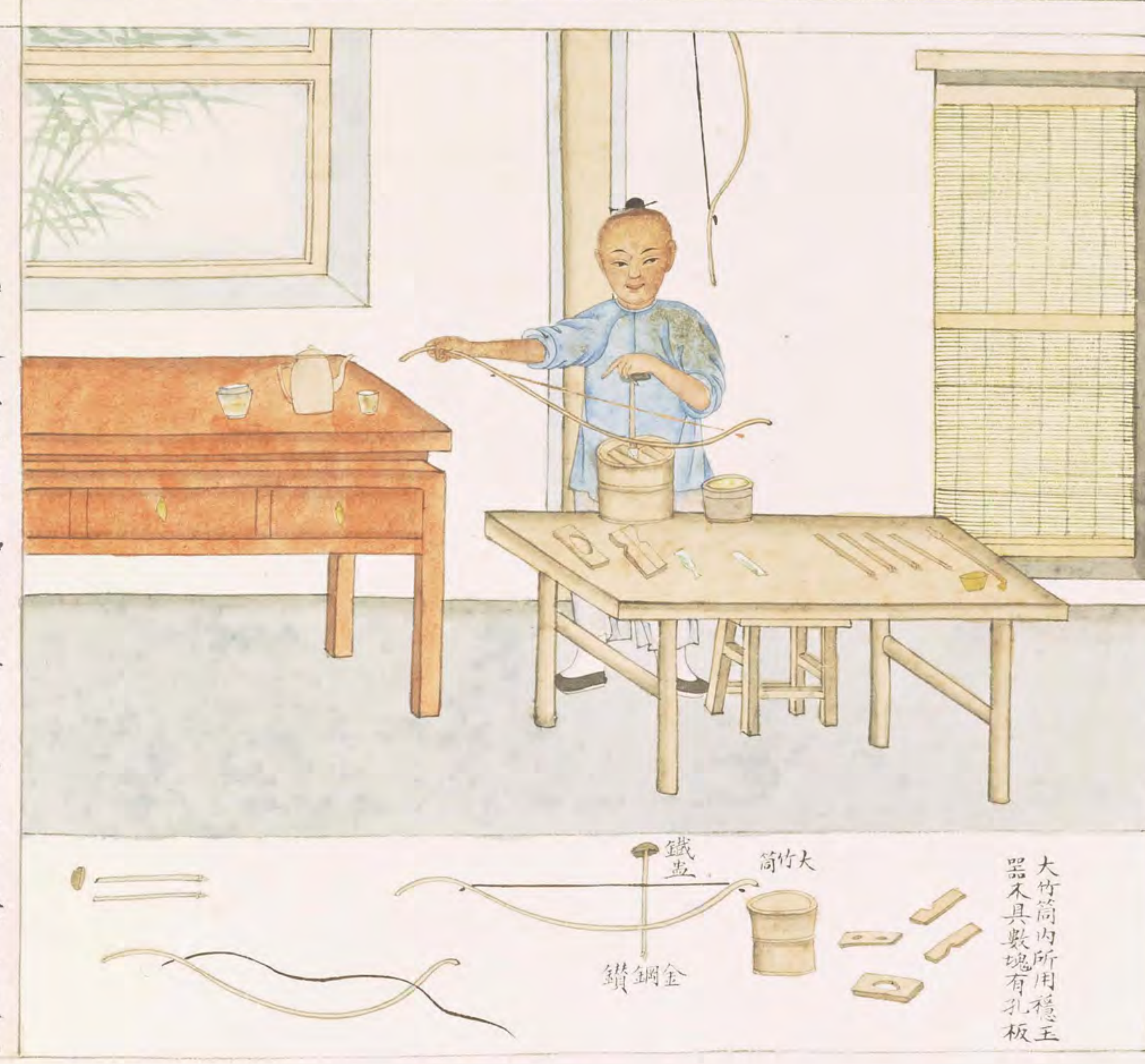
凡玉片宜作透花者先以鋼鑽將玉片鑽透圓孔後以彎弓絣鋼絲一條用時則解鋼絲一頭隨將絲頭穿過玉孔復結好絲頭于弓頭然後用浸水沙順花樣以搜之如木作彎鋸搜花一樣

圖內桌上有豎木桌拿子或橫木桌拿以穩住玉器



十一 打眼圖說

凡小玉器如烟壺班指烟袋嘴手不能扶拏者皆用七八寸高大竹筒一個內注清水水上按木板數塊其形不一或有孔或有槽窩皆像玉器形臨作工時則將玉器按在板孔中或槽窩內再以左手心握小鉄盅按扣金鋼鑽之丁尾用右手拉綳弓助金鋼鑽之打眼



XII. THE WOODEN POLISHING WHEEL

When the grinding wheel has done its work, although the surface of the jade is smooth and uniform, yet it has no bright gloss, and the wooden wheel must be used, with yellow diamond dust or with a paste made of one of the colored sands, to give it a polish. If the jade article is too small to be polished on the wooden wheel, or if the pattern of the design is very small and complicated, so that the wooden wheel cannot be used, then a small wheel is made of a piece of dry gourd-skin to polish it.

N. B. Two wooden polishing tools, adapted to be mounted in an iron rod for polishing the interior of vases, etc., are figured below, in addition to the wheel described above.

XIII. THE LEATHER POLISHING WHEEL

This is a picture of the leather wheels which give the bright polish. These wheels are made of four or five layers of ox leather sewn together by hempen cord. They vary in size from over a foot in diameter down to two or three inches, and are all used with a paste made of the "precious-stone dust" mixed with water for polishing the jade. After it has been polished on the leather wheel, the jade acquires a bright glossy surface of warm, uniform color, such as is most highly appreciated by cultured collectors. This is the finishing touch of artistic work in jade, and completes the cycle of work.

十二 木碢圖說

鋼碢磨畢玉體雖平净然尚欠光亮即用木碢及浸水黃

實料或用各色沙漿以磨之

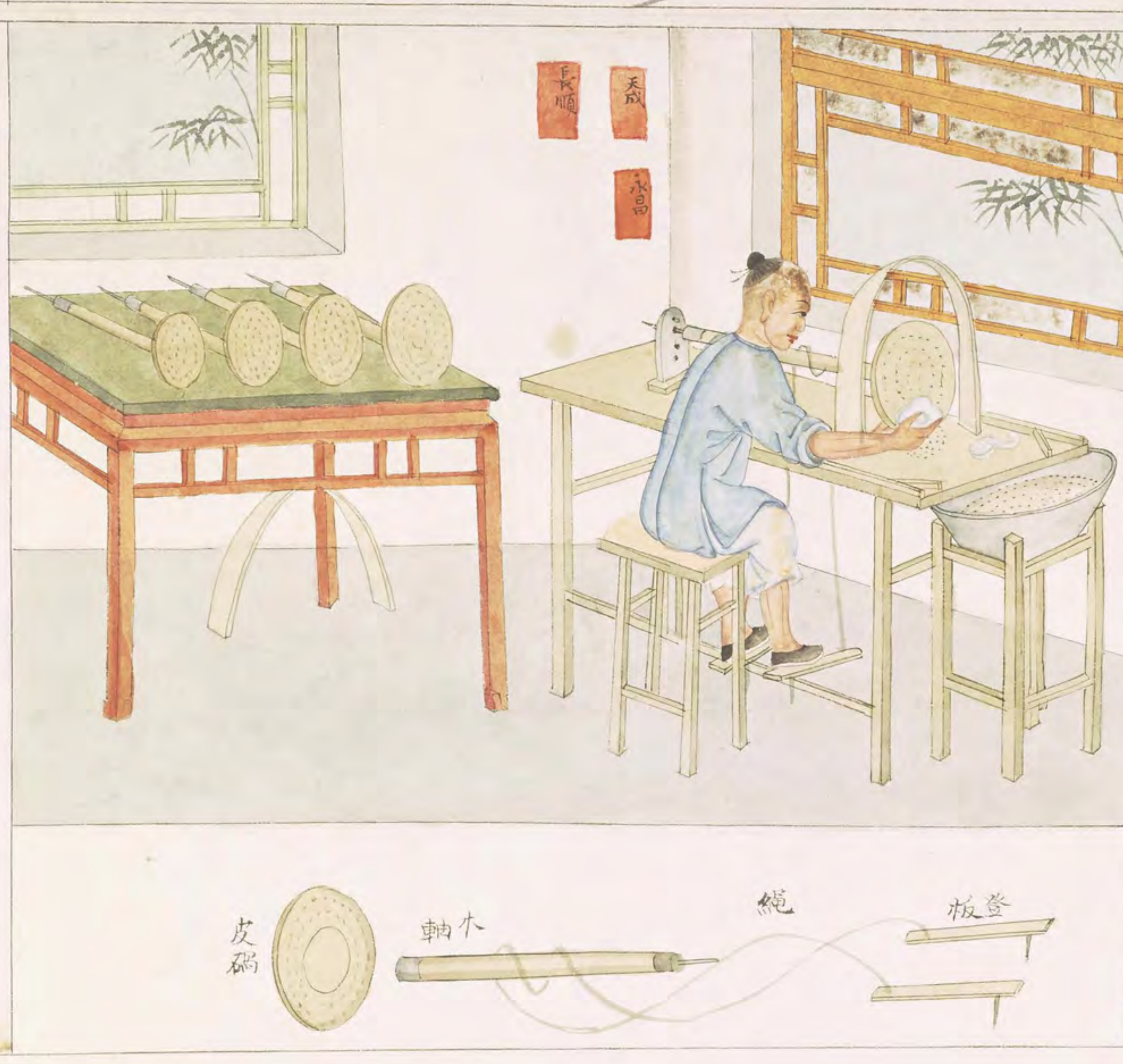
若小件玉器不能用木碢磨之或有甚細密花樣者皆不

可用木碢磨之則以乾葫蘆片作小碢以磨之

十三 皮碢圖說

此係皮碢磨亮上光之圖也碢係牛皮為之包于木碢之上

納以麻繩大者尺餘見圓小則二三寸不等皆用沁水寶



料磨之皮碢上光後則玉體光亮溫潤使鑒家愛之無窮

至此則琢磨工事畢矣


PRANG · BOSTON

No. 606

PILGRIM BOTTLE

(*Pei Hu P'ing*)

Ch'ien-lung (1736–95)

Nephrite

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PART III

JADE AS A MINERAL

BY GEORGE FREDERICK KUNZ, A.M., Ph.D.

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No. 120

PART OF THIN SLAB

Nephrite

Siberia

No. 71

ROUGH FRAGMENT

Nephrite

Turkistan

No. 150

FRAGMENT

Nephrite

Lake Neuchâtel, Switzerland

No. 14

SMALL FRAGMENT

Jadeite

Burma

No. 104

FRAGMENT OF BOULDER

Nephrite

Siberia

No. 4

FRAGMENT OF BOULDER

Jadeite

Upper Burma

No. 141

FRAGMENT

Nephrite

Jordansmühl, Silesia

No. 97

FRAGMENT OF BOULDER

Nephrite

Probably Turkistan

71

JADE AS A MINERAL

GENERAL DEFINITION

JADE is a term generally employed to designate a number of minerals of tough, compact texture and of color varying from nearly white to very dark green, which have been used from the earliest times in worked forms as weapons, utensils, and ornaments. The term, however, properly includes only two species, jadeite and nephrite, and it is to a study of these minerals that the greater part of the following pages is devoted.

Jadeite and nephrite are chemically quite distinct substances, but notwithstanding this fact they are strikingly alike in many of their properties. Both are hard and compact and usually of distinctly fibrous texture, owing to which they are exceedingly tough, and may be carved into very delicate forms. Both are more or less translucent in most of their varieties, and are of various colors, although shades of green are most characteristic for both. In thin sections all varieties of both minerals appear nearly or entirely colorless and quite transparent. Both minerals are susceptible of taking a high polish, and the polished surfaces frequently exhibit a very characteristic sheen.

In addition to the many characters shared by both minerals, each has properties peculiar to itself, which may be briefly stated.

Jadeite is a silicate of aluminium and sodium. It almost always contains in addition small quantities of iron, calcium, and magnesium; in the variety called *chloromelanite* the iron amounts to as much as ten per cent. Its chemical composition and crystalline character make it a member of the pyroxene group of minerals. It occurs very rarely in distinct crystals, its usual form being a crystalline aggregate of more or less density. Its hardness is about 7, or that of quartz. Its specific gravity is close to 3.33. It fuses readily before the blowpipe to a clear glass, and is not decomposed by hydrochloric acid until after having been fused.

Nephrite is a silicate of calcium and magnesium, with generally a small amount of iron replacing magnesium. It belongs to the amphibole group of minerals, being identical in composition with the minerals tremolite and actinolite of that group. It is distinguished from them solely by its structure, which is always that of a closely felted, compact aggregate of fine fibres, never in discrete crystals as are those minerals. Its hardness is 6.5. Its specific gravity is close to 3.0. It fuses with some difficulty to a greenish glass, and is not decomposed by hydrochloric acid.

It is evident from this outline of the characteristics of jadeite and nephrite that the strong resemblance which has caused them to be classed together under the common name of *jade* is due to comparatively superficial characters; but the certain discrimination between them often requires a more or less complete investigation of all their properties, chemical and physical. This discrimination becomes the more difficult owing to the fact that the two substances not infrequently occur intermixed in the same specimen, the nephrite having been formed from the jadeite by a gradual alteration of its chemical and physical constitution. In such cases it is only by means of the study of thin sections with the microscope that it is possible to discover the true nature of the mineral.

Before beginning the account of the investigations of jade it will be well to review briefly the history of the jade minerals, and show by what slow stages their present place in the mineralogical system has been reached.

The claim that the jasper of the ancients was jade is hard to disprove, because in olden times, as in China even at the present day, great looseness prevailed in the classification and naming of minerals. Mere outward appearance and chiefly color formed the basis of classification, and it is not improbable that the term *jaspis* may have included many minerals now known by other names, and amongst them jade. Support for this is found in the fact that Marco Polo, in the thirteenth century, in describing the localities of Eastern Turkistan, now known to be the chief source of supply of the jade used by the Chinese, speaks of the minerals found there as "Jasper and Chalcedony." It is true he does not describe the mineral itself, but his description of the jade-rivers of Khotan corresponds so closely with the descriptions of other and much later observers that there can be no doubt in the matter.

In the year 1569 came the Spanish phrase-name *piedra de hijada*, rendered in French by *pierre de jade*, from which has come our English word *jade*, and as confirming the jasper classification of jade, Sir Hans Sloane, writing in 1725 on the Natural History of Jamaica, calls piedra de hijada *jaspis viridis*, or "green jasper."

The real separation of jasper and jade seems to have occurred about the end of the sixteenth century, when the term *Lapis nephriticus* came into use as the equivalent apparently of the Spanish phrase-name *piedra de hijada*, with its implication of therapeutic properties. Boetius de Boodt, writing in 1609, has a chapter on *Jaspis*, and another on *Lapis nephriticus*. Clutius (1627) has a separate treatise on *Lapis nephriticus*, and Jan de Laet (1647) treats of both *Jaspis* and *Lapis nephriticus*. The Forsters, father and son, who had accompanied Captain Cook on two of his voyages to New Zealand, called the New Zealand material "green talc," and spoke of it as "jadde"; and about this time the name *Beilstein*, or "hatchet-stone" (found in Emmerling, 1793), came into use, the mineral receiving this name, as Hoffman tells us in his "Handbuch der Mineralogie" (1812), from the sharp implements for which it was used in New Zealand. In the year 1789 Werner and his pupils introduced the name *nephrite*, and placed the mineral in his talc group between talc and serpentine. Haüy in 1801 recognized several varieties of "jade," but was unable to give the mineral a definite place in his system. Glöcker in 1831 placed it among the feldspars, but the first correct analyses, made in 1844 by Schafhautl and Rammelsberg, showed the falsity of the classification, and it was then given a place among the pyroxenes by Hausmann, and in the amphiboles by Damour. Still the matter was uncertain, and it was not until 1863 that Damour, after a study of the specimens brought to France as part of the loot obtained when the Summer Palace near Peking was destroyed in 1860, established by new analyses that two distinct minerals had been included in the term *jade* (or *nephrite*), one of which he showed to be near tremolite in its composition and therefore an amphibole, the other a new mineral which he named *jadeite* and showed to be near diopside in its composition, and probably a scapolite or a pyroxene.

From this time nephrite was generally recognized as an amphibole closely allied to tremolite, its com-


PRANG · BOSTON

No. 487

SMALL "DOUBLE-GOURD" VASE

(*Hu Lu P'ing*)

Probably Ch'ien-lung (1736–95)

Jadeite

No. 355

WATER-RECEPTACLE

(*Hsi-tzŭ*)

Ming Dynasty (1368–1644)

No. 366

CUP

(*Pei*)

Ming Dynasty (1368–1644)

Jadeite-Quartzite

No. 349

MINIATURE BRUSH-POT

(*Pi T'ung*)

Supposed to be Sung Dynasty (960–1278)

Nephrite

No. 402

DISH

(*Hsi-tzŭ*)

Ming Dynasty (1368–1644)

Nephrite

No. 651

SMALL "LONGEVITY" FIGURE

(*Shou Lao*)

Ch'ien-lung (1736–95)

Nephrite

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position as well as its structural features being gradually determined. Kengott, Dana, and Berwerth all contributed to this view.

The systematic position of jadeite remained uncertain until 1881, when Des Cloizeaux, by a determination of its cleavage and optical characters, proved that it belonged to the pyroxene group. He was unable, however, to determine whether it was monoclinic or triclinic in its crystallization, and this question remained unsettled. Arzruni's studies led him to believe that it was triclinic, and his results were accepted, though with some doubt, by Hintze and Dana. Bauer and others made observations which did not confirm this result, however, and it remained for Penfield, while studying some specimens from this Collection, to settle the question in favor of the monoclinic system by the direct measurement of a crystal of jadeite, as described in a later page of this work.

The subspecies chloromelanite was established by Damour in 1865 and has always been accepted since then as a variety of jadeite rich in iron.

The dual nature of the material composing the objects to be described in the present work must be kept in mind in reading the following pages, in which will be found full descriptions of the properties of both jadeite and nephrite, the two being considered successively under each separate heading.

COLOR

Jadeite.—The color of jadeite is highly diversified, exhibiting an almost indefinite variety of shades and tints. The commoner colors, however, are tones of white and various shades of green.

Pure white is not common. A silvery white, translucent like chalcedony, is shown in the Chinese bowl, No. 488 of the Collection. Such specimens are known as "camphor jade."

Sugar-white material having the appearance of that variety of marble known as saccharine is occasionally found. No. 23, a fragment from Burma, is of this character.

Grayish-, greenish-, bluish-, or yellowish-white tones are more frequent than the pure white. Examples are very numerous. Gray of various tones is found, as in parts of No. 364, a Chinese vase dating from the Ming dynasty.

A pale-lavender color is especially characteristic of the Burmese jadeite, and is highly prized. Specimens of this tint are generally translucent and highly crystalline, giving a frosted appearance on polished surfaces. Nos. 486, a tiny figure of the god of longevity; 487, a small double-gourd vase; and the eight wine-cups numbered 715 are good examples. Patches of the lavender tint are often intermingled with green, as in No. 503.

Many shades of green occur in jadeite. Specimens are found colored a pale grayish-green, as in the cylindrical brush-holder No. 516; lettuce-green, as shown in the quadrangular vase No. 430, the flower-vase No. 364, and the miniature dish No. 520; apple-green, in the gourd-shaped vase No. 363; grass-green, in the covered cup No. 726; and pea-green, in Nos. 523 and 722.

Emerald-green is the most prized color both for its beauty and its rarity. A good example is the incense-burner, No. 428. It sometimes occurs in small patches in the midst of white or otherwise colored material, as in Nos. 355, 425, 427, 499, and many others. The jewelled jades, No. 733, are cut from masses of very translucent and uniformly colored deep emerald-green, and are probably the finest examples extant. Emerald-green is the *fei-ts'ui* of the Chinese, and is among their most highly valued varieties of jadeite.

Greens of darker tone are less common in jadeite.

In No. 362 blue and brown are seen as mottlings in light gray.

A bluish-lavender color is peculiar to the so-called Tibetan material, which is remarkable for its wonderful delicacy. A beautiful example illustrating this color is No. 799, the small figure of the Venus de Milo made in Paris for the Collection.

The two bowls, Nos. 494 and 495, are a delicate greenish-blue, with irregular veins of rich moss-green tint from one to twelve millimetres in length. To such coloring the Chinese have given the poetical descriptive name of "melting snow enclosing bits of moss." The large dish of chrysanthemum pattern, No. 492, is another example.

Transitions from the greens to decided tones of yellow are uncommon. Yellowish-green of strong tone is seen in the rice-bowl numbered 423.

The variety of jadeite called chloromelanite is characterized by containing a large percentage of iron, replacing in part its aluminium. As its name implies, it is of dark-green color, often appearing quite black, except in the thinnest splinters, when it is seen to be of a slightly translucent blackish-green color. No. 219, a long, narrow axe from Mexico, is a typical example of this color.

Nephrite.—The color of nephrite varies almost as widely as does that of jadeite, but is characterized by the greater frequency of darker shades of green. White is much more frequent than in jadeite, yet pure white is rare. Very faint tones of greenish-, bluish-, and grayish-white are more common than pure white. The Collection furnishes numerous examples of these, of which several may be mentioned: *e. g.*, the beautiful beaker-shaped vase, No. 439; the altar-set of three pieces numbered 594, 595, and 596, as well as No. 756, and many others.

Pale yellow of waxy aspect, varying somewhat in tone, is exceedingly rare, yet the Collection includes several beautiful examples, of which Nos. 397, 398, 399, and 400 may be mentioned.

Gray, which is somewhat rare, is well exemplified in Nos. 417, 460, and 463. It is chiefly due to minute inclusions of opaque black particles in a white matrix, and varies in depth of tint according to the abundance of inclusions. It is thus often speckled or clouded, as in the bowl numbered 767. The rich gray is often in combination with inky black, as in the little cylindrical pen-holder, No. 349. A very light yellowish-gray is seen in No. 634, and an opaque greenish-gray in Nos. 337 and 641.

Brown of various shades occurs. Pale-brown transparent material of horn-like consistency is very characteristic. It is shown in No. 646, an ornamented musical stone. Darker tints are shown in Nos. 319 and 351, and are specially apt to occur as stainings or veins in material of other colors,—green, yellow, white,—as is seen in Nos. 416 and 651. Tints of gray and brown in irregular mixtures are often found in nephrites that have been exposed to great heat or that have long lain in the earth, in contact perhaps with other substances, such as the ancient Chinese pieces to which Dr. Bushell has given the name *tomb jades.* In such specimens are found grayish- and brownish-yellows, often with veinings or stainings of russet or dead-oak-leaf brown.

Nos. 316, 317, and 318 are typical of this class.

All the foregoing colors are, however, comparatively rare, the most typical nephrites being of some shade of green. Olive-green is seen in Nos. 465 and 466; seaweed-green, in Nos. 71, 160, and others; golden emerald-green, as in No. 659; spinach-green, in Nos. 409, 663, and 666; sage-green, in Nos. 464 and 648; light sage-green, in Nos. 407, 640, and 762; dark sage-green, in Nos. 468, 670, and 763; and dark green to greenish-black, as in Nos. 172, 765, and many others.

Many of these green colors occur very uniformly in considerable masses of the mineral. Again, two or more tints are found commingled, and such varieties have been likened by the Maoris to "moss seen at the bottom of a pool of limpid water." This description might apply to No. 416 and others. The rich, transparent emerald-green of the *fei-ts'ui* jadeite is not found of equal purity in nephrite, those which approximate to this color having always a yellowish cast.

The entire Collection, when arranged on a color basis only,—that is, regardless of form, date, locality, or substance,—formed a series presenting an almost continuous gradation from white of many different tones through yellow, gray, and green of various shades and mottlings to black. The nephrites predominated in whites with tints of lavender, gray, or green, and nearly all the dark grass- or sage-greens or the grays resulting from inclusions of chromic iron or other materials in the white magma, the brilliant greens, emerald-greens, and light greens in a white field belonged to the jadeite group.

The following notes specially prepared for this work by Professor F. W. Clarke, Chief Chemist to the United States Geological Survey, explain all that is known as to the origin of the various colors observed in jadeite and nephrite, which may be considered as natural colors—that is, those produced at the time of crystallization of the minerals and due to their peculiar chemical composition or to original inclusions within their substance.

NOTES ON THE COLOR OF JADE

Absolutely pure jadeite should be white, without a tinge of color. So also an ideal nephrite, containing only lime and magnesia, should be colorless. The colors which actually exist are due to admixtures of other substances, and in general terms they are not difficult to explain. Occasionally, however, anomalies seem to exist. At all events, the analytical data which are given do not in every case account for the color or lack of color observed.

The colorific agents to which jade owes its different hues are mainly the compounds of iron, of manganese, and of chromium. Manganese is relatively unimportant. Were silicates of manganese present in sufficient quantities, they would impart to jade a pinkish or amethystine tint; but in all observed cases they serve merely to modify the colors produced by iron. The latter are enfeebled by the presence of manganese, but not to any very great degree in this group of minerals. Free oxides of manganese are black; and they in small amounts might give a grayish cast to jade, or even appear as black stainings. Finely disseminated chromite may also account for black and gray colorations; but chromium is much more important as the source of the brilliant emerald-green of certain jadeites. This particular tint is probably always due to chromium, which has been repeatedly identified in the jade by Damour, by Von Fellenberg, and by myself; although in the analyses of material from the Collection its determination seems to have been overlooked or neglected.

To the compounds of iron most of the colorations of jade are due. As included magnetite, finely subdivided, iron may give black and gray tintings. As ferric hydroxide it produces yellows and browns. Ferrous silicates yield colorations ranging from pale green to almost black, and ferric silicates offer shades of yellow, brown, and black. Some silicates of iron are blue, but this tint is not common. Since iron may occur in more than one condition in a single specimen of jade, it is evident that a great variety of blendings are possible, and that the amount of iron present will not alone account for the color seen. In general, the green jades, excluding the emerald-green, owe their color to ferrous silicates; and the quantity of the latter determines the depth of the shade. With ferric silicates in small amount, yellows and browns appear; and these, commingled with the ferrous greens, may give many intermediate shades. Ordinary bottle glass, green and brown, offers good examples of the character of the colors which are here seen separately; and it is easy to realize how a blending of the two in one melting-pot would yield a wide range of hues; brown and green tending in part to neutralize each other. In the coarser varieties of bottle glass the colors appear to advantage only by transmitted light; by reflected light the material is black or nearly so. Since jade is not transparent, it is seen only by reflected light, and dark shades are produced by relatively small amounts of the colorific agent.

Although the principles thus laid down concerning the colorations due to iron are simple enough, their application to the actual analyses is exceedingly difficult. In general, the white or light-colored jades are low and the darker specimens high in iron. In this statement surface stainings are left out of account. The difficulty about interpreting analyses more closely is due to our lack of knowledge as to the way in which the iron is actually combined; the representation of it as oxides being but a conventional and partial statement of the truth. Thus a jade might contain 1.60 of ferric oxide, and 0.72 of ferrous, and this could mean one of several things. The two oxides might be united as magnetite, forming black inclusions, and giving a gray coloration. Or both might be combined as silicates, with another result as to color. Or the ferrous oxide might represent a ferrous silicate, while the ferric oxide was combined with water in the form of rust. To determine exactly the true state of affairs would be difficult, and in some cases even hardly possible. In fact, all three of the conditions above suggested might co-exist, and then their disentanglement would be almost hopeless.

Upon careful scrutiny of the analyses, various anomalies appear which so far are not explainable by the evidences now in the hands of the writer. Take, for example, the four following cases in the annexed table, and contrast the proportion of iron with the reported color:

No.	Ferric Oxide	Color
80	4.10	White, with very faint grayish tint.
120	4.28	Seaweed-green, clouded with brown.
159	3.99	Light green.
765	3.64	Dark greenish-black.

These differences of tint are extraordinary. First, a sample high in iron is white, and another somewhat lower in iron is nearly black. Ferrous oxide is not reported in any of the four, and yet greens appear in three of the specimens. It would seem on the face of the reports as if ferrous iron had been neglected, all the iron having been estimated in the ferric state. But this supposition does not account for No. 80, which, upon general principles, ought to be deeply colored.

In other cases the results obtained by analysis are more satisfactory. For example, four specimens of jade are described as seaweed-green, and their contents of iron and manganese are shown in the table herewith.

No.	Ferric Oxide	Ferrous Oxide	Manganese Oxide
104	4.93	0.11	....
120	4.28	....	trace
71	4.64	0.16	0.38
160	3.39	0.85	0.22

Here there is a decided family resemblance, although the indications are for brown tints rather than the green which actually occurs. But, as has been already indicated, the mode of combination of the iron is uncertain; and perhaps a more careful scrutiny of the samples would explain the colors found. On this subject the last word has evidently not been said.

Concerning some of the more unusual and delicate shades which occur in jadeite and nephrite there is little to say. The evidence for their interpretation is lacking. Possibly some of the pale yellows may be due to titanium; but the blues and lavenders are unexplained. Some silicates of iron are blue or bluish, and vanadium might give similar hues. Glaucophane, which Professor Penfield has identified in some of the nephrites, is often blue or lavender; crocidolite is dark blue; and the presence of either would account for the observed phenomenon. Brown stainings and streakings are caused by ferric hydroxide; and surface blackening is often attributed to carbon derived from organic matter. In some cases a grayish tint may be produced by microscopic inclusions of mica. Such inclusions have been observed, but they are not very common.

In addition to the natural colors treated of by Professor Clarke in the foregoing, there is another group of colors which are due to agencies of various sorts affecting the jade after its formation, such as weathering, absorption of coloring materials either natural or artificial, and the action of fire. To some one of these agencies or to a combination of them are due most of the veins or stainings, chiefly in tones of gray, brown, and black, to which reference has already been made.

The presence in worked jade of these colors, streaks, etc., is not always a detriment, inasmuch as lapidary-artists, especially in China, are in the habit of carefully selecting such parts of a specimen as have stains, tints, and markings of brown and yellow, and very skilfully taking advantage of the coloring to add an additional charm to the leaf, the finger-tip, fruit, or any ornament which is to be given a prominent place in the perfected object. This adaptation of material to design, and of design to material, is splendidly exemplified in the Collection.

The effects of weathering and the absorption of natural stains are best exemplified by the group of specimens in the Collection to which the name of *tomb jades* has been applied. Such objects are generally of great antiquity, and have been subjected to the altering agencies during long burial in the earth in tombs or in the ruins of ancient cities.

A natural staining may be the result of the infiltration of oxide of iron, manganese, or other substances, while the jade is still in the bed-rock; or while it is being rolled along in the bed of a river after being detached from the bed-rock; or, lastly, while buried in the ground.

Another remarkable change of color is that due to calcination, generally the result of conflagration. A notable example of this, the small quadrangular vase, No. 395, was recovered after the looting and destruction of the Summer Palace at Peking in 1860. In this object the lower part is a light grayish-green, with a black staining that is due to infiltration in the cracks where the piece had been subjected to slight heat or staining from pyroligneous and other acids produced by the conflagration, but was not brought into direct contact with the fire. The upper part, however, which has suffered actual contact, changed to a yellowish but opaque substance, resembling calcined bone. An extreme example of this kind is the tiny incense-burner, No. 394, which has been so much altered as to have lost almost all trace of its ever having been jade. The delicate carving remains, however, and the polish is still there to a great extent; but the whole piece is now a minutely crackled grayish-white opaque substance, almost resembling a jasper-like substance such as porcellanite.

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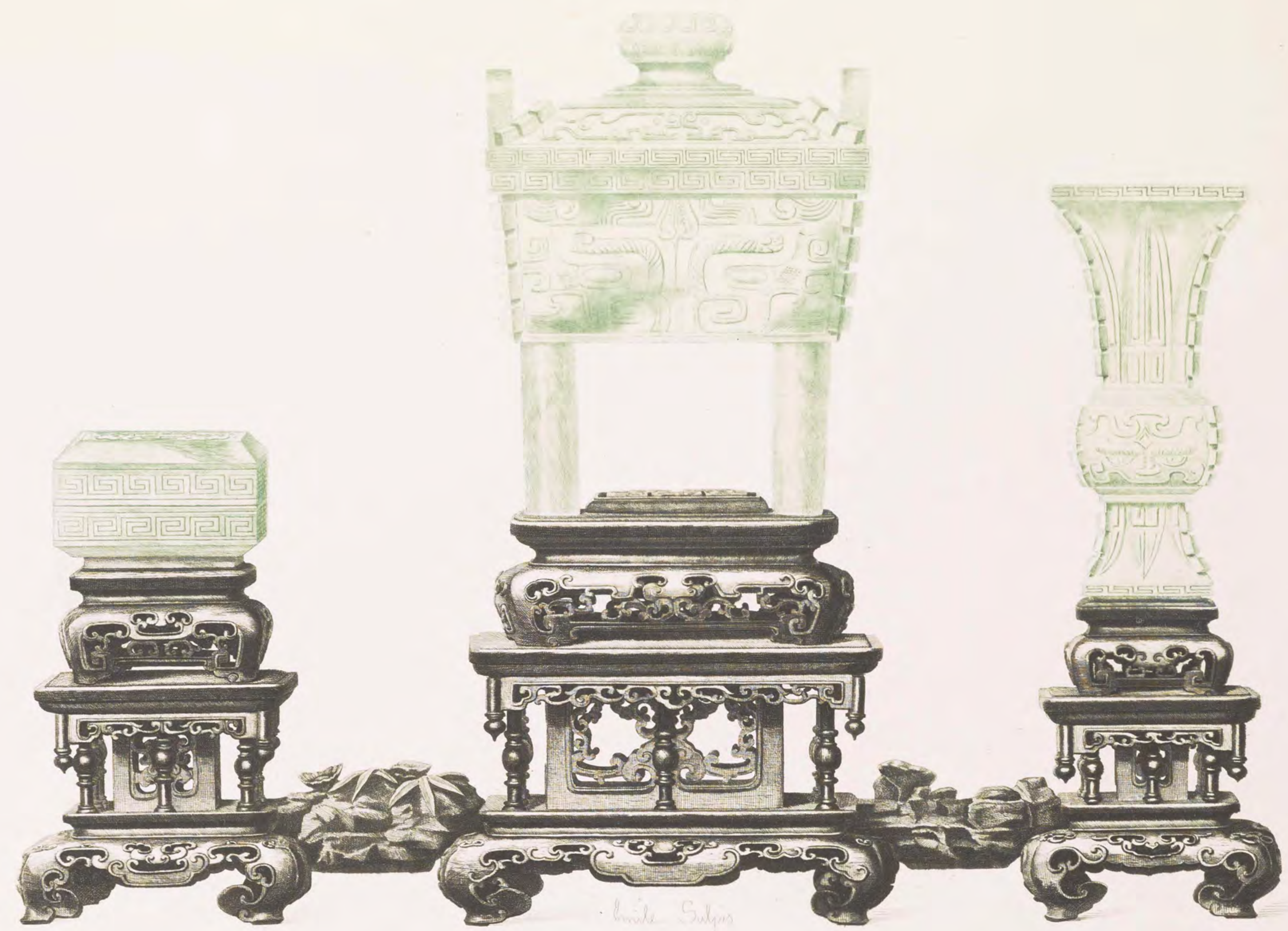
Nos. 499, 500, 501

ALTAR SET

(San Shê)

Ch'ien-lung (1736–95)

Jadeite



DIAPHANEITY

THE degree of transparency of the jade minerals varies considerably with the color and structure of individual specimens. Unpolished specimens of all colors are at best only translucent and more commonly quite opaque except in very thin splinters. But the removal of the inequalities of the surface by polishing greatly heightens the translucency.

Jadeite is, on the whole, less translucent than nephrite. The light-colored varieties are generally subtranslucent to translucent, having in this respect much the character of chalcedony. But some of the white jadeites are quite opaque; and, on the other hand, in some of the coarser-grained varieties, such as No. 715, single perfectly transparent crystals of considerable dimensions may be seen embedded in the translucent matrix.

In green jadeites a subtranslucent character is more common, extending in the chloromelanite variety to a more or less pronounced opacity. But the rare emerald-green jadeite as seen in the Kleczkowsky jewels, No. 733, is sometimes almost perfectly transparent, nearly rivalling the emerald in both color and water.

The nephrites may be more uniformly described as translucent, the degree of translucency depending on the depth of the color and the thickness of the specimen. White, semi-transparent varieties are sometimes found, as in the little cup, No. 544, which is so transparent that print held against the back of the specimen may be read through a thickness of two or three millimetres of material.

The same quality of semi-transparency is seen in some of the green varieties, notably those from New Zealand, which the Maoris have picturesquely likened to "a clear stream on whose bottom green moss and grasses luxuriate."

Such semi-transparent or highly translucent specimens are termed *precious nephrite*, but their quality never equals that of the emerald-green jadeite. Many of the more massive pieces of worked nephrite appear opaque because of their thickness only, the edges or thin fragments always showing a pronounced translucency.

LUSTRE

THE lustre of both jadeite and nephrite on fresh fractures is dull and wax-like, with very few reflecting surfaces. Polished jadeite has ordinarily a vitreous lustre, while nephrite when polished frequently exhibits an oily lustre as if it had been rubbed with oil. This oily appearance is highly characteristic of many of the green nephrites.

OPALESCENCE

OPALESCENCE, lacking however the play of color, is sometimes to be observed on polished specimens of both jadeite and nephrite. It may be likened to the light effect obtained when some finely veined, naturally colored, translucent, Oriental chalcedonies are viewed by transmitted light. An admirable example illustrating this property is the framed jadeite screen, No. 493. The specimen is a mixture of large irregular patches of a white and a lavender-tinted material through which are long, irregular veinings of rich translucent sea-green, in part almost opaque when quite thick. By reflected light a large part of the surface exhibits a pinkish-lavender opalescence, which is remarkably pleasing and beautiful.

SHEEN

IT is characteristic of many minerals, such as crocidolite, chrysotile, and satin-spar (fibrous gypsum), which have a parallel-fibrous structure, that on polished surfaces the light is reflected with a peculiar lustre comparable to the sheen of raw silk. It results from a distortion of the light-figure reflected from the uneven surface of the individual fibre. When such substances are cut with a domed surface—*en cabochon*, as it is called—the reflection takes the form of a band or streak of light which changes its position as the stone is moved. Nephrite, owing to its fibrous structure, sometimes exhibits such a sheen, occasionally so strongly

as to suggest the possibility of obtaining by proper cutting a jade cat's-eye. In rare instances where the fibres are twisted and curved into approximately circular forms an effect like that termed *asterism* by jewellers is produced.

Numerous examples of this quality of sheen are contained in the Collection. A typical example of sheen is No. 183, a nephrite hatchet found among the remains of the ancient pile-dwellings at Neuchâtel. In this beautiful gray shimmering sheen is seen on both faces, evidently caused by the reflection of the light from the many minute lamellæ or folia of which the piece is made up. The crude nephrite fragment No. 150, from Neuchâtel, has one black weathered surface, but the reverse has a remarkably brilliant sheen apparently due to minute fractures nearly parallel to its surface. Perhaps the most beautiful example in the Collection illustrating the sheen is No. 285, the nephrite axe from the North Island, New Zealand. By reflected light it shows a silky structure. The material is as finely fibrous in one direction as a compact New Zealand actinolite. It exhibits a sheen and a chatoyancy comparable to that of a greenish chrysoberyl cat's-eye if cut into a gem of similar form. No. 186, the lake-dwellers' chisel from Neuchâtel, exhibits a brown pearly sheen by reflected light; while the hatchet from the same locality, No. 180, has a peculiar green sheen. A beautiful satiny sheen in large patches, due to the reflection of light from the large fibres, may be seen in the two wine-cups, Nos. 693 and 694.

Peculiar internal reflections due to other causes are found in both jadeite and nephrite. In the sinewy or horn-like varieties of nephrite the parting planes which traverse the mineral in various directions often cause an almost white, a golden, or a yellow reflection. The same effect is produced where the mineral has been bruised by pounding with a stone or other blunt instrument, the fracture surfaces, which are generally round in shape, giving dull reflections.

Again, inclusions of foreign minerals, such as the very common black crystals of chromite or mica scales, are the cause of characteristic internal reflections.

CRYSTALLINE SYSTEM AND OPTICAL PROPERTIES

Jadeite

Except for the information gained by the study of thin sections under the microscope, our knowledge of the crystalline character of jade has up to the present time been limited, as distinct crystals have not been available for study. The angle of the prismatic cleavage has been given by Des Cloizeaux[1] as 85° 20′, by Krenner[2] as 86° 55′, and by Arzruni[3] as 86° 56′ to 87° 20′.[4] Attention has been called to a specimen of jadeite said to have come from Tibet, No. 51 of the Collection, which possesses in places a somewhat coarser crystalline structure than the mineral usually exhibits. On breaking up some of this material two crystals were found, from which the data necessary for the determination of the exact crystalline character of the mineral could be determined, and the results of their study by Professor S. L. Penfield given herewith are of much value. The crystals were prisms measuring about two millimetres in length and half a millimetre in diameter, and the isolated ones were terminated only at one end by crystal faces. They were colorless and had a vitreous lustre. They belong to the monoclinic system of crystallization, and their habit is represented by Figs. 1 and 2, as shown in the adjoining cut. The forms that were observed are similar to those which occur on pyroxene and ægirite, and are as follows: The orthopinacoid a (100), two prisms m (110) and n (130), with two faces of the monoclinic pyramid s (111) forming the termination.

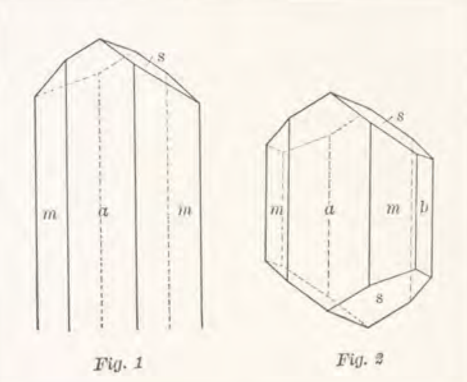


Fig. 1 Fig. 2

Considering the small size of the crystals, the reflections from their faces were good, and the axial ratio may be considered therefore as very nearly exact. The following axial ratio was derived from the measurements marked in the accompanying table by an asterisk. For the sake of comparison there

[1] Bulletin de la Société Minéralogique de France, 1881, Vol. IV, p. 158.
[2] Flugblatt, April, 1883.
[3] Zeitschrift für Ethnologie, 1883, Vol. XV, p. 186.
[4] For a full list of observations of this angle, see the table of recorded cleavage and extinction angles annexed to the chapter.

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No. 628

SCREEN

(*Ch'a P'ing*)

Ch'ien-lung (1736–95)

Nephrite

78

are also given the axial ratios of the closely related minerals of the pyroxene group: Ægirite, from the nepheline, syenite of southern Norway, by Brögger.[1] Pyroxene (variety augite), from Vesuvius, by Von Rath.[2] Spodumene, from the old locality at Norwich, Mass., studied by J. D. Dana.[3]

	a		*b*		*c*	β = 100 ∧ 001
Jadeite	1.103	:	1	:	0.613	72° 44½′
Ægirite	1.097	:	1	:	0.601	73° 9′
Pyroxene	1.092	:	1	:	0.589	74° 10′
Spodumene	1.124	:	1	:	0.635	69° 40′

The measurements that were made are as follows:

	Measured	*Calculated*
a ∧ *m*,	100 ∧ 110 = 46° 29′*	
m ∧ *m*,	110 ∧ 1$\bar{1}$0 = 92° 38′–93° 10′	92° 58′
m ∧ *m*,	110 ∧ $\bar{1}$10 = 86° 51′–87° 13′	87° 2′
a ∧ *n*,	100 ∧ 130 = 72° 25′	72° 26′
n ∧ *n*,	130 ∧ $\bar{1}$30 = 34° 43′	35° 8′
n ∧ *n*,	130 ∧ 1$\bar{3}$0 = 145° 26′	144° 52′
s ∧ *s*,	$\bar{1}$11 ∧ $\bar{1}\bar{1}$1 = 61° 12′*–61° 5′	61° 12′
a ∧ *s*,	100 ∧ $\bar{1}$11 = 76° 56′–77° 10′	76° 59′
m ∧ *s*,	$\bar{1}$10 ∧ $\bar{1}$11 = 58° 23′*–58° 13′	58° 23′
m ∧ *s*,	$\bar{1}\bar{1}$0 ∧ $\bar{1}$11 = 102° 37′–102° 10′	102° 21½′

The close crystallographic relationship of jadeite, ægirite, and pyroxene is shown not only by the similarity in their axial ratios, but also by the fact that their crystals have almost the same habit. A common development of the ægirite crystals from Norway is exactly like Fig. 1, and Fig. 3 represents the ordinary habit of augite (pyroxene) crystals.

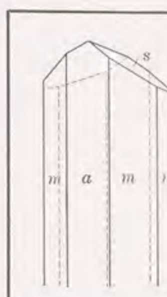

Fig. 3

The optical properties of the crystals correspond to monoclinic symmetry. A crystal lying on its pinacoid face *a* (100) shows an extinction parallel to its prismatic edges when examined under the microscope in polarized light. In convergent light one of the axes of a biaxial interference figure may be seen rather near the limit of field. The plane of the optical axes is the clinopinacoid (010). When supported, with the symmetry plane horizontal, in a liquid of high index of refraction, the extinction angle was found to be 34° from the vertical axis in the obtuse angle β.[4] The divergence of the optical axis 2V was found to be approximately 70°. This was determined by supporting a short section of a crystal in oil by means of the device described by Professor C. Klein,[5] and turning it until the optical axes came into the centre of the field. The direction of one of the optical axes coincides almost exactly with the vertical axis.

It may be added that twinning has been observed by Max Bauer[6] in jadeite from Tammaw in Upper Burma. It follows one of the usual twin laws of pyroxene, twinning plane the basal pinacoid, and is repeated in thin lamellæ, producing what are known as polysynthetic twins similar to those common in plagioclase feldspar. Twinned prisms were frequently found bent throughout and fringed at the ends. It appears that the twins were most numerous in the portions that had suffered the greatest crushing, and were absent where the effects of pressure were not well marked. We must conclude, therefore, that under favorable conditions crushing and pressure would produce in the jadeite a rearrangement of the molecules into twins similar to that observed in calcite. This, however, must have happened only in rare cases, for it has not hitherto been observed.

Nephrite

All mineralogists agree in classifying nephrite as a variety of the monoclinic amphibole *actinolite*, whose chemical and, in general, physical properties it possesses. The distinction of nephrite as a variety is based on its structure alone, it being characterized by a very fine fibrous texture, the fibres being generally so curved and interwoven as to render it exceedingly tough. The extreme fineness of the fibres makes it difficult, even with high magnification in thin section, to obtain satisfactory observations of the cleavage; and the same cause, together with the frequently curved character of the fibres, makes the extinction angles somewhat uncertain. Most of the observations in the annexed table to which any degree of reliability may be attached were made upon larger isolated crystals of actinolite embedded in the nephrite substance.

The angles given by the principal text-books for actinolite, and therefore to be accepted for nephrite, are given in the corner table on the succeeding page.

[1] Zeitschrift für Mineralogie und Krystallographie, 1889, XVI, p. 318.
[2] Poggendorf's Annalen, Erganzungs, 1873, Band VI, p. 340.
[3] System of Mineralogy, sixth edition, p. 366.
[4] For other observations of this angle, see the table given on the following page.
[5] Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, 1891, Vol. XXIV, p. 435.
[6] Jahrbuch für Mineralogie, 1896, Vol. I, p. 21.

	Prism (cleavage) angle	Angle of extinction to cleavage in clinopinacoid section
Dana,[1]	55° 49′	15°
Hintze,[2]	55° 49′	16°–18° 30′
Levy et Lacroix,[3]	55° 49′	15°

Dana considers that some nephrite may belong to the amphibole *tremolite*, the extinction angle of which is 16°–18°.

The cleavage angle and optical properties, especially the extinction angle in sections parallel to the clinopinacoid, of jadeite and nephrite are the most important properties for their determination in microscopic sections. The first of the two tables which follow contains all the observations of these two values given by various authors in the large literature of "Jade," and the second contains a record of the extinction angles measured by Mr. R. D. George from the micro-sections made from specimens in the Collection and studied by Professor Iddings.

The measurements given below in Table I of both cleavage and extinction vary widely in their reliability. Observations made in thin sections of minerals are liable to an error, which cannot be checked, due to imperfect orientation of the section to the direction desired. This error is to a certain extent eliminated if a large number of observations of different crystals in the section is taken; but in many of the observations quoted there is no satisfactory evidence that care in this direction has been taken.

The observations are arranged in the table in order of the date of publication, the jadeites being grouped separately from the nephrites. The angle given under the heading of "extinction" is, in all cases where not otherwise stated, the angle of extinction against the trace of the cleavage in sections parallel to the clinopinacoid. In Table II the specimens are grouped first as jadeites and nephrites, and then according to locality, with descending size of the extinction angle.

I. TABLE OF RECORDED CLEAVAGE AND EXTINCTION ANGLES

No.	Material	Locality	Character of Material	Observer	Angle of Cleavage	Angle of Extinction	Reference	Remarks
1	Jadeite	Probably Asiatic	?	H. Fischer		20°–34°	Zeitschrift für Krystallographie, 1880, iv, 371	Monoclinic. First determination of crystal system
2	Jadeite	Tibet?	Raw material. Cleavage measured on isolated fibres	Des Cloizeaux	85° 20′	31°–32°	Bulletin de la Société Minéralogique de France, 1881, p. 158	Monoclinic (or triclinic?). Also poor cleavage parallel to clinopinacoid
3	Jadeite	Rabber, Hanover	Axe; private ownership	A. Arzruni	86° – 89° 25′	On basal section angles of 35° and 54° to the two cleavages	Zeitschrift für Ethnologie, Berlin, 1881, p. 281	Triclinic because cleavages were not equal and extinction unsymmetrical
4	Jadeite?	Unteruhldingen, Switzerland	Axe — material mixed with quartz and not certainly jadeite	"	82° about	36°	Zeitschrift für Ethnologie, Berlin, 1882, xiv, 566	
5	Jadeite	Upper Burma	Raw material	Krenner	86° 55′	33° 34′	"Flugblatt," 9 April, 1883, Abstract Jahrbuch für Mineralogie, 1883, ii, 173	Monoclinic
6	Jadeite	Lüscherz	Material not homogeneous	A. Arzruni	87°– 89°	38° 5′	Zeitschrift für Ethnologie, Berlin, 1883, xv, 186	
7	Jadeite	Orient	Measurements made on isolated fibres with goniometer	"	85° 56′	33°–40°	" " "	Cleavages unequal. Triclinic?

[1] System of Mineralogy, 1892, p. 389. [2] Handbuch der Mineralogie, 1894, pp. 1186 ff. [3] Les Minéraux des Roches, 1886, p. 144.

I. TABLE OF RECORDED CLEAVAGE AND EXTINCTION ANGLES (*Continued*)

No.	Material	Locality	Character of Material	Observer	Angle of Cleavage	Angle of Extinction	Reference	Remarks
8	Jadeite	Mogaung, Upper Burma	Raw material, original of Damour's analysis. Cleavage measured on fibres with goniometer	A. Arzruni	86° 56′–87° 20′	35° (average) 41° (highest) On basal section, angles of 34° and 48° to the two cleavages	Zeitschrift für Ethnologie, Berlin, 1883, xv, 186	Triclinic. Cleavages unequal and extinction unsymmetrical in basal section
9	Jadeite	Mexico	Average of many specimens	"	85° 30′	32°–35° On basal section, 35° and 50° to the two cleavages	" " "	" "
10	Jadeite?	Burma	Called amphibole paramorph after jadeite on account of cleavage	"	55° 30′		" " "	Cleavage probably measured between prism and pinacoid, hence discordant result (about half)
11	Jadeite	Neuenberger Lake, Switzerland	Axe	"	Pyroxene cleavage	18° 30′–30° 30′	"Antiqua," Zürich, 1884	
12	Jadeite	" " "	Raw material	"	" "	On basal section, 24° 30′ and 64° 30′ to the two cleavages	" "	Triclinic on same grounds as above
13	Jadeite	Central Italy	Axe?	"	86°	34°	Zeitschrift für Ethnologie, Berlin, 1884, xvi, 358	
14	Jadeite	Tibet	Raw material	M. Cohen	"Almost rectangular"	41° maximum	Jahrbuch für Mineralogie, 1884, i, 71	Monoclinic
15	Jadeite	Burma	Raw material in Freiburg Museum	Schoetensack	87°	35°	Zeitschrift für Ethnologie, Berlin, 1885, xvii, 162	
16	Jadeite	"Little Tibet"?	" " "	"	Pyroxene cleavage	43°	" " "	
17	Jadeite	Hissarlik	Worked fragment	A. Arzruni		28°–35°	Zeitschrift für Ethnologie, Berlin, 1886, xviii, 136	
18	Jadeite	Oaxaca, Mexico	Bead in National Museum, Washington	Clarke and Merrill	"Nearly at right angles"	35°–40°	Proceedings of U. S. National Museum, 1888, p. 115	Monoclinic
19	Jadeite	Zaachita, Mexico	" " "	" "	Pyroxene cleavage		" " "	" "
20	Jadeite	Sardinal, Costa Rica	Fragment " "	" "	" "	35°–40°	" " "	" "
21	Jadeite	Barencamp, near Wesel, Germany	Axe owned in Dresden	Lossen for A. B. Meyer	87° about	40°–43°	Abhandlungen und Berichte der Königlichen und Ethnologischen Museum zu Dresden, 1890–91, No. 1	

I. TABLE OF RECORDED CLEAVAGE AND EXTINCTION ANGLES (*Continued*)

No.	Material	Locality	Character of Material	Observer	Angle of Cleavage	Angle of Extinction	Reference	Remarks
22	Jadeite	Schafhausen, near Aachen, Germany	Axe in City Museum of Aachen	Arzruni for A. B. Meyer	"Nearly at right angles"	40° maximum	Abhandlungen und Berichte der Königlichen und Ethnologischen Museum zu Dresden, 1890–91, No. 1	
23	Jadeite	Stotsheim, Alsace	Axe in Dresden Museum	" "	" "	"	" " "	"Altogether like the axe from Schafhausen"
24	Jadeite	Tammaw, Burma	Raw material	Max Bauer	"Augite cleavage"	"	Jahrbuch für Mineralogie, 1896, i, 21	Monoclinic because cleavages are equal and extinction in basal section symmetrical to the cleavages
25	Nephrite	Irkutsk, Siberia	" "	Jannetaz and Michel		11° about	Bulletin de la Société Minéralogique de France, 1881, iv, 178	Measured on isolated fibres
26	Nephrite	Murthal, Steiermark, Styria	" "	A. Arzruni Berwerth		12° 17°	Mittheilungen der Anthropologischen Gesellschaft zu Wien, 1883, xii, 217	
27	Nephrite	Potsdam, Germany	Glacial boulder?	A. Arzruni	52°–56½°	15°–17°	Zeitschrift für Ethnologie, Berlin, 1883, xv, 180	Measured on larger crystals embedded in fibrous aggregate
28	Nephrite	Eslohe, Germany	" "	"	60° about	up to 14° 50′	" " "	" "
29	Nephrite	Dresdener Apotheke, probably Asiatic (Meyer)	Raw material	"		13° 15′–18°	" " "	Nephrite derived by alteration of a pyroxene (?)
30	Nephrite	"Turkei," Leipzig? probably same as last (Meyer)	" "	"	44½°	10° 30′	" " "	Measured section oblique and angles therefore too small
31	Nephrite	Bjelaja River, Siberia	" "	"	51°–55¼°		" " "	Larger crystals in slide
32	Nephrite	New Caledonia	?	"		17° 30′ about	" " "	
33	Nephrite	Alaska	Axe in Bremen Museum	Arzruni for A. B. Meyer		"Nearly parallel"	21st Jahresberichte der Vereins für Erdkunde, Dresden, 1884	
34	Nephrite	Jordansmühl in Silesia	Raw material	H. Traube	55°–57°	12°–16°	Jahrbuch für Mineralogie, Beilage Band, iii, 1884, p. 420	Crystal boundaries as well as cleavage seen in section
35	Nephrite	Manas (Dsungarei)	Worked material in Freiburg Museum	Schoetensack		12°–16°	Zeitschrift für Ethnologie, Berlin, 1885, xvii, 157	

I. TABLE OF RECORDED CLEAVAGE AND EXTINCTION ANGLES (*Continued*)

No.	Material	Locality	Character of Material	Observer	Angle of Cleavage	Angle of Extinction	Reference	Remarks
36	Nephrite	Khoten, Bucharei	Worked (?) material in Freiburg Museum	Schoetensack		16°	Zeitschrift für Ethnologie, Berlin, 1885, xvii, 157	
37	Nephrite	Kowak River, Alaska	Raw material in U. S. National Museum, Washington	Clarke and Merrill		0°–15°	Proceedings U. S. National Museum, 1888, p. 115	
38	Nephrite	New Zealand	" " "	" "		0°–20°	" " "	
39	Nephrite	Ak-Deniz, N. Syria	Axe in Dresden (?) Museum	Arzruni for A. B. Meyer		17° about	Abhandlungen und Berichte der Königliche zoologischen und Ethnologischen Museum zu Dresden, 1890–91, No. 1	One crystal showed an extinction of 41½°
40	Nephrite	Schahidulla-Chodja, K'un Lun Mts.	Raw material	A. Arzruni		"Practically parallel"	Zeitschrift für Ethnologie, Berlin, 1892, p. 23	Fine fibrous ground mass
					56°	11°–16°	" " "	Crystals embedded in above

II. TABLE OF OBSERVED EXTINCTION ANGLES

No.	Material	Locality	Description	Specific Gravity	Highest Angle of Extinction	Remarks
41	Jadeite	China	Part of medallion	3.3303	43° 45′	
490	Jadeite	China	Plate	3.3373	43° 10′	
485	Jadeite	China	Dish	3.3381	42° 10′	
42	Jadeite	Burma	Fragment of pendant	3.3287	41° 35′	
497	Jadeite	China	Vase	3.3328	40° 30′	
523	Jadeite	China	Sceptre	3.2657	41° 00′	
51	Jadeite	Tibet	Crude fragment	3.3359	40° 10′	
496	Jadeite	China	Bowl	3.3394	40° 00′	
362	Jadeite	China	Vase	3.3316	36° 30′	
14	Jadeite	Burma	Crude fragment	3.2991	42° 30′	
16	Jadeite	Burma	" "	3.2578	41° 00′	
18	Jadeite	Burma	Boulder fragment	3.1223	40° 35′	Chemical analysis shows mixture of about half jadeite with other silicates. Extinction angles probably belong to jadeite
4	Jadeite	Burma	" "	3.2175	40° 30′	
43	Jadeite	Burma	Fragment of pendant	3.3309	40° 30′	
7	Jadeite	Burma	Boulder fragment	3.3122	35° 15′	
219	Jadeite	Mexico	Axe	3.3034	42° 00′	
303	Jadeite?	Mexico	Mask	2.8320	41° 00′	Chemical analysis shows jadeite mixed with equal parts of albite feldspar, hence low specific gravity
188	Jadeite	Switzerland	Chisel	3.3832	36° 50′	
177	Jadeite	Switzerland	Hatchet	3.3745	34° 10′	Readings approximate because of fine granular form
328	Nephrite and Jadeite	China	Libation-cup	2.9587	43° 00′	Extinction angles probably read on few jadeite crystals embedded in nephrite mass
97	Nephrite and Jadeite	China	Boulder fragment	2.9825	40° 30′	All but two readings of extinction angles above 18° 10′ and probably made on jadeite crystals embedded in nephrite

II. TABLE OF OBSERVED EXTINCTION ANGLES (*Continued*)

No.	Material	Locality	Description	Specific Gravity	Highest Angle of Extinction	Remarks
449	Nephrite and Jadeite	China	Sculptured rock-mass	2.9549		Readings fall into two groups: 00° 00′–15° 40′. . . .Nephrite? 21° 25′–40° 30′. . . .Jadeite?
330	Nephrite and Jadeite	China	Thumb-ring	2.9896	39° 15′	High extinction angle probably observed on small amount of jadeite shown to be present by analysis
601	Nephrite	China	Vase	2.9552	34° 10′	High extinction angle may have been observed on small amount of jadeite which may be present
317	Nephrite	China	Part of a kwei	2.9430	18° 10′	One reading gave 26° 45′, probably obtained from jadeite shown by analysis to be present in small amount
84	Nephrite	China	Worked fragment	2.9630	18° 30′	One reading gave 25° 00′, probably obtained from jadeite which might be present in small amount
322	Nephrite	China	Carved celt	2.9506	18° 15′	One reading gave 24° 25′, probably obtained from jadeite shown by analysis to be present in small amount
80	Nephrite	China	Worked fragment	2.9706	16° 30′	One reading gave 24° 00′, probably obtained from jadeite shown by analysis to be present in small amount
81	Nephrite	China	" "	2.9520	13° 00′	One reading gave 22° 00′, probably obtained from jadeite shown by analysis to be present in small amount
630	Nephrite	China	Small dish	2.9564	16° 00′	One reading gave 20° 00′, probably obtained from jadeite shown by analysis to be present in considerable amount (14%)
351	Nephrite	China	Wine-jug	2.9243	18° 20′	
336	Nephrite	China	Tomb jade	2.9629	17° 00′	Large part parallel. Measurements from coarser scattered fibres
531	Nephrite	China	Sculptured mass	2.9574	17° 00′	In this section many fibres with extinction of 12° 00′–15° 00′+
648	Nephrite	China	Round dish	2.9758	16° 30′	Large part parallel
96	Nephrite	China	Boulder fragment	2.9690	16° 30′	" " "
443	Nephrite	China	Vase	2.9539	16° 00′	" " "
581	Nephrite	China	Screen	2.9609	15° 00′	
331	Nephrite	China	Tomb jade	2.9309	14° 00′	
83	Nephrite	China	Broken medallion	2.9546	13° 00′	Large part parallel
401	Nephrite	China	Wine-cup	2.9497	6° 00′	Readings approximate
71	Nephrite	Turkistan	Boulder fragment	3.0033	15° 00′	Large part parallel
765	Nephrite	India	Sword-guard	3.0783	15° 00′	" " "
59	Nephrite	India	Fragment of worked piece	2.9951	11° 00′	
280	Nephrite	Siberia	Adze	2.9673	16° 00′	
104	Nephrite	Siberia	Boulder	3.0138	15° 30′	
120	Nephrite	Siberia	Slab from boulder	3.0070	14° 00′	Large part apparently parallel; measurements uncertain owing to curved fibres
281	Nephrite	Siberia?	Hatchet	3.0076	11° 00′	Large part parallel; readings approximate only
283	Nephrite	Siberia?	Knife	3.0150	00° 00′	Apparently all parallel; extinctions not sharp
182	Nephrite	Switzerland	Hatchet	3.0118	14° 00′	Largely parallel
198	Nephrite	Switzerland	"	2.9035	13° 00′	Mainly parallel
205	Nephrite	Switzerland	Knife	3.0037	8° 00′	Measurements approximate
180	Nephrite	Switzerland	Hatchet	3.0034	00° 00′	Extinction is parallel with the fibres

II. TABLE OF OBSERVED EXTINCTION ANGLES (*Continued*)

No.	Material	Locality	Description	Specific Gravity	Highest Angle of Extinction	Remarks
183	Nephrite	Switzerland	Hatchet	2.9836	00° 00′	Apparently parallel, but impossible to make good measurements
141	Nephrite	Jordansmühl	Crude fragment	2.9451	15° 30′	
234	Nephrite	British Columbia	Chisel	2.9987	12° 00′	Large part parallel
153	Nephrite	Alaska	Crude fragment	2.9487	00° 00′	Measurable fibres all parallel
155	Nephrite	Alaska	" "	2.9604	?	Section too thick and too finely fibrous to afford readings of any value
160	Nephrite	New Zealand	Slab	3.0103	15° 00′	A good deal is parallel
299	Nephrite	New Zealand	Boulder fragment	3.0000	15° 00′	Finer fibres mainly parallel
162	Nephrite	New Zealand	" "	3.0122	15° 00′	Readings approximate
289	Nephrite	New Caledonia	Axe	2.9311	13° 00′	Large part parallel; measurements uncertain owing to curving of fibres

STRUCTURE

Reference has already been made to the fact that both jadeite and nephrite are known only as massive aggregates of crystalline particles, and never as complete crystal individuals. The structure of these aggregates varies considerably, and presents some characters which are peculiar to one or the other mineral; but in far the greater number of cases the grain of the mass is too fine to permit of the recognition of the character of the individuals composing it by the unaided eye or even with the assistance of a lens. In such cases it is necessary to have recourse to the microscope, studying the structure in thin section. The paper by Professor Iddings on the Microscopical Petrography of Jade, which follows, treats in full of the characters thus observed, which are among the most important means of distinguishing between the jade minerals, and throws a flood of light on the origin and history of both jadeite and nephrite.

The macroscopic structural features are more readily observed and may be dismissed with a much briefer treatment.

Jadeite.—The structure of jadeite is either granular or fibrous, the former being the more characteristic. It may be studied to the best advantage in such thin, translucent, highly polished objects as the bowls, cups, and plates which are so abundantly represented in the Collection. On holding such a specimen against a light, each crystal composing it stands out from its neighbors quite sharply, owing to the fact that the light strikes the surface and cleavages of each one at a different angle, giving each a slightly different appearance. Thus examined, we see that the individual grains are sometimes of prismatic shape—that is, with one diameter much longer than the others; sometimes equidimensional, with diameters up to three millimetres in exceptional cases such as No. 41.

Generally the grains interlock at their edges, the boundary between any two being jagged and irregular in the extreme. In very rare cases, however, as in No. 51, already referred to by Professor Penfield, the individual grains of jadeite do not come into immediate contact, but each has developed its own crystal boundaries, and the complete crystals are cemented by a small amount of an undetermined interstitial mineral.

In those specimens in which the grains are prismatic the prisms are more or less interwoven and often curved; when the prismatic development is so pronounced that the individuals become fibrous, the structure is best described as felted, since the fibres intermingle in the most confused manner; at the same time the grain becomes finer, so that the eye cannot readily separate the particles.

In the granular jadeites the grain varies, even in parts of the same specimen, from the coarsest to the finest, patches of large granules often occurring like "eyes" in a fine-grained mass.

A rather fine granular structure of very uniform character is the ordinary and typical structure for jadeite; distinctly fibrous specimens, in which the grain is coarse enough to be distinguished even with the lens, being so rare as to be noteworthy. The beads, No. 44, show this latter character well.

Nephrite.—The structure of nephrite is characteristically fibrous and of such fine grain that the individual fibres are but rarely visible except under the microscope. The fibres are arranged in the aggregate in many ways: parallel to one another over considerable areas, tufted or in fan-shaped groups, or curved, twisted, interlocked, and felted in most intricate fashion. But all these arrangements of fibres are visible under the microscope only, and the coarser visible structures are due to groups of fibres, although dependent largely for their origin on the intimate internal structure.

The visible structures are of several distinct types. A marked bedded or slaty structure results from the parallelism of the fibres in distinct layers, adjacent layers having a different direction of the fibres. As a consequence of this structure the mass can be cut more easily along the plane of the "bedding" than across it; and it is a noticeable fact that in art objects the artist generally arranges his designs so that the principal cutting will be across this bedding, thus making the object stronger and more enduring; and in the making of cylinders and vases from which a central core is to be removed by the use of a cylindrical drill, the core can be more readily broken out or detached from the mass. The same is true of the prehistoric workman, many of the objects left by him showing that the flat sides are parallel with the bedding of the material because the fashioning of the celt or other object was not only more easily done in this way, but the workman was surer of success in the operation.

A sinewy or hornlike appearance is extremely common and characteristic in nephrite, being visible on both rough and polished surfaces. It seems to be due to the grouping of fibres in tufted or fan-shaped bundles, sometimes of considerable size and separated from one another by indistinct parting surfaces which are often curved into irregular forms.

An apparent granular structure in some nephrites is shown to be due generally to the alteration of original jadeite to nephrite, each relatively larger granule of jadeite becoming a mass of interwoven fibres which retains some of its individuality. The great significance of this alteration is fully treated in the following section on the microstructure of jade.

A peculiar type of nephrite which markedly differs from the normal in its appearance is that termed by collectors *puddingstone jade.* By transmitted light specimens of this variety show nodular areas, varying from the size of a pin up to two inches across, of a golden-yellow nephrite cemented together by a dark olive-green variety of the same mineral which occasionally has brighter grass-green streaks. This apparent nodular structure is evidently due simply to color differences, the result probably of alterations in the state of oxidation of the iron in the mineral, progressing from numerous isolated centres. While therefore not strictly a structural modification of nephrite, the variety is so distinct as to be held worthy of more than passing notice. The specimens in this Collection which illustrate this peculiar feature are Nos. 413, 414, 664, 674, and 683.

The compact texture and the extraordinary toughness of both jadeite and nephrite are clearly due directly to the character of their structure, the intimate intergrowth of their constituent particles, whether fibrous or granular, producing a similar result in these respects. But the fibrous nature of the nephrite substance gives it properties of cohesion altogether superior to those of jadeite, as will be shown later.

MICROSCOPICAL PETROGRAPHY OF JADE

THE microscopical study of the jade in the Collection was made upon one hundred and ninety-two thin sections, which were prepared from pieces sawn from the jade objects, and represent one hundred and five different specimens. Of these, twenty-three are jadeite, and the remainder nephrite; a number consisting of both minerals. The microscopical investigation was undertaken by Professor J. P. Iddings as a purely petrographical study, without reference to ethnological theories, and without knowledge as to the localities from which the specimens were collected. The results are, therefore, independent of any preconceived ideas

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No. 641

DRAGON AND PHENIX VASE

(Lung Fêng P'ing)

Ch'ien-lung (1736–95)

Nephrite

regarding the source of the material. With the exception of a specimen of jadeite containing microscopic garnets, from Lake Neuchâtel, all the specimens examined are so related petrographically that they might have been parts of one and the same mass of rock. Nevertheless, it must not be forgotten that rocks which are identical mineralogically and chemically occur in widely distant parts of the earth.

The pure jadeite specimens consist of precisely similar pale-green pyroxene, which is almost colorless in thin section. The slight variations in size of grain are only such as often occur in different parts of one rock mass.

The coarser-grained forms that are microscopically alike are from China (Nos. 41, 43, 496), and from Burma (No. 16 and possibly No. 4); while another form from Burma (No. 14) and one from Mexico (No. 219) differ only slightly from these. Other jadeites from China and Burma are identical with one another and are somewhat finer-grained (Nos. 9, 24, 26, 32, 42, 44, 362, 485, 490, 497).

A review of the specimens of nephrite shows that those varieties exhibiting most clearly the metamorphism of jadeite into nephrite come from China. Microscopically identical nephrites, consisting of confused aggregations of amphibole fibres, having a faint suggestion of the patches derived from previous jadeite come from Eastern Siberia (No. 280), Lake Constance (No. 198), China (Nos. 82, 83, 99, 401), New Zealand (No. 299), British Columbia or Alaska (No. 234), and China or possibly from India (No. 648). Nephrites that are microscopically alike in being composed of parallel fibres, that are sometimes curved, are from Siberia (No. 283), New Zealand (Nos. 160, 162), India (No. 59), and Lake Neuchâtel (Nos. 182, 183). Another group that have like microscopical structure includes specimens from New Caledonia (No. 289), Siberia (No. 120), Irkutsk, Siberia (No. 104), India (Nos. 648, 765), and China (No. 336).

From these examples it is evident that varieties of jade from widely distant parts of the earth, when studied in thin sections, are in some cases identical, even to the most microscopic detail. But it is to be remarked that the pronounced differences in shades of color that characterize different specimens of jade when studied in mass, disappear almost completely when the jade is cut into sections 0.001 of an inch in thickness. When the color is intense in the mass it may be recognized as slight coloring of the almost colorless minerals; but less pronounced variations of color are not distinguished in the thin sections.

It is also to be noted that jade from some countries varies in its composition and microstructure from jadeite to fibrous nephrite; similar variations occurring in different countries.

The following is a systematic description of the thin sections studied microscopically. They are arranged without regard to locality, but according to their mineralogical composition and microstructure. The jadeites are described first, and then the transitional modifications that demonstrate the metamorphism of the jadeite into nephrite. Then the more and more fibrous varieties of nephrite. Owing to the microscopical identity of some of the specimens, certain of them are classed together and described at one time.

The photomicrographs which illustrate this part of the work were taken with oxyhydrogen zircon light on orthochromatic plates, using a yellow screen. They nearly all represent the appearance of the thin sections of jade as seen in plane polarized light between crossed nicols, and have a magnification of sixty diameters.

The sections which exhibit most plainly the true character of the pyroxene mineral or jadeite are those made from No. 4. The thin section, 0.022 millimetre thick, is transparent in part, and partly greenish-white. Under the microscope the rock is seen to consist of an aggregation of irregularly shaped crystals of nearly colorless pyroxene with many cracks. The cracks follow the outlines of the crystals, the prismatic cleavage, and a transverse parting, probably basal. In places the pyroxene crystals become long prisms, and lie at all angles in the section; sometimes being grouped in fan-like aggregates or bundles. In several places they lie embedded in a colorless mineral, which acts as a matrix for the pyroxene crystals. In these places they have sharply defined crystal forms. The long prisms are well developed in the prismatic zone, and have the orthopinacoid (100) and unit prisms (110); and sometimes the clinopinacoid (010) less pronounced. Thus they are sometimes flattened parallel to the orthopinacoid. Terminal planes were not observed. Cross-sections exhibit distinct prismatic cleavage. The form of the crystals is similar to that of ægirite, from which this pyroxene differs by being colorless in thin sections. Cross-sections exhibit the emergence

of an optic axis when examined in convergent polarized light. Longitudinal sections yield a maximum angle of extinction of about thirty-five degrees. Hence the angle between the optic axes is about seventy degrees. Longitudinal sections that have been cut nearly perpendicular to an optic axis exhibit the plane of the optic axes parallel to the side of the prism, indicating a monosymmetric crystal. One of these crystal sections also exhibits narrow lamellæ, parallel to the sides of the prism, which appear to be the result of twinning parallel to the orthopinacoid. They also exhibit a transverse parting nearly at right angles to the prism.

These crystals, magnified sixty diameters, are shown in photomicrographs Nos. 4*a* and 4*b* in the accompanying Plate A. Several small cross-sections are seen. The matrix appears as a uniformly gray mineral. Photomicrograph No. 4*c* in the same plate shows the granular portion of the same rock magnified the same amount. It consists wholly of colorless jadeite, and was photographed in polarized light between crossed nicols. In photomicrograph No. 4*a* the nicols were nearly parallel.

The colorless mineral acts as a cement or matrix for the jadeite prisms, and appears to consist of relatively large individuals, not an aggregate of small ones. It has a low index of refraction, and very low double refractory. In places it is twinned in polysynthetic lamellæ, making ninety degrees with one another. The exact nature of this mineral is not determinable by optical means alone. It is possibly analcite; this is further indicated by the chemical analysis.

The coarsest-grained variety examined is No. 41. It is an aggregate of colorless jadeite crystals that can be seen without the aid of a lens; the largest crystals being three millimetres long. The size of the crystals varies greatly, from that just mentioned to microscopic dimensions. The large and small crystals are intimately mingled without any definite arrangement, or any suggestion of a porphyritic structure. The sections of some of the large crystals are nearly free from cleavage cracks, while others are crowded with them. The section is about 0.055 millimetre thick, and the polarization colors are brilliant, ranging into yellows and reds of the second order. This indicates a double refraction of about 0.019. Some of the crystals exhibit a slight undulatory extinction. Cross-sections show that the prismatic cleavage is perfect. The substance of the jadeite is very pure and free from inclusions in most crystals; a few show minute specks that seem to be due to incipient decomposition, which results in the clouding of the crystals by particles that appear white by incident light. These crystals are not twinned, and there are no other minerals present. The chemical analysis shows that the rock is ninety-eight per cent. pure jadeite.

Another coarse-grained form is represented by the so-called galvanized or frosted specimem, No. 496. The crystals are about the size of the largest in that just described (No. 41), or three millimetres in diameter. There are fewer small crystals. Undulatory extinction is a pronounced characteristic. The rock has evidently been subjected to great straining forces. Large cross-sections with prismatic cleavage cracks resolve themselves between crossed nicols into aggregates of jadeite with slightly different optical orientations. They break up into optical "fields" (*Felder erscheinungen*), and may be traversed by several lines indicating distinct ruptures. In some longitudinal sections this same mottling is very pronounced, in others it resembles more closely the curved mottling of bird's-eye maple, so characteristic of mica-sections. The resemblance is often deceptive, but other characteristics prove the pyroxenic nature of the mineral. There has also been developed a delicate lamination which is plainly due to twinning in thin plates parallel to the orthopinacoid. The striations are sometimes straight, sometimes curved. There seems to be a second twinning inclined to the first, which produces less distinct striations. (This is most likely parallel to the basal plane.) This appears to be connected to some extent with the mottled effect. In places the rock has been crushed and dragged, producing streaks of fine grains and particles of pyroxene, that have the same color, index of refraction, and double refraction as the large crystals. Here the pyroxene has been crushed to powder that has been compacted, and is indistinguishable by the unaided eye from the other parts of the rock, and is scarcely distinguishable from the larger crystals without the use of crossed nicols. The jadeite has been crushed by dynamic forces without having the crystallographic character altered. The rock exhibits a partial dynamic metamorphism without any signs of chemical or mineralogical metamorphism.

In another thin section of this same specimen (No. 496) the large jadeite crystals exhibit the same mottling between crossed nicols, and twin lamination whose curved forms bear a direct relation to the lines

No. 330
Nephrite
China (?)

No. 322
Nephrite
China (?)

No. 4 A
Jadeite
Upper Burma

No. 4 B
Jadeite
Upper Burma

No. 4 C
Jadeite
Upper Burma

No. 188
Jadeite
Lake Neuchâtel, Switzerland

MICROSECTIONS

of rupture in the rock, where fine fragments of jadeite, and brilliantly polarizing fibres of the same mineral, form veins through the rock and act as cement between the unbroken larger crystals.

A rock of almost the same character is No. 43. It consists wholly of irregularly shaped crystals of colorless jadeite, averaging two millimetres in size, and exhibiting undulatory extinction and twinned lamination produced by dynamical stress. There is a small amount of crushed jadeite as cement. An incipient decomposition has clouded the central parts of some crystals to a slight extent. Another thin section of the same specimen exhibits more of the crushed jadeite, and some of the crystal grains are colored light green and are faintly pleochroic between bluish-green and yellowish-green. The color is not related to any change in the interference phenomenon. Some of the larger crystals contain numerous fluid inclusions which are long and narrow and are arranged parallel to the axis of the crystal. Where these inclusions are crowded together there is a clouding similar to that already alluded to, suggesting that these fluid inclusions are secondary.

A slightly different modification of the jadeite aggregate is found in No. 14. It consists of large and small irregular crystals of pyroxene, the small ones acting as a kind of cement in some parts of the rock. In other places there is an approach to an orderly arrangement of the crystals in several directions, the somewhat prismatic crystals appearing as though woven together. There are besides acicular microscopic prisms that traverse the rock in several directions; a number of the needles enclosed in one jadeite specimen being parallel to one another. These needles are colorless amphibole or actinolite. They have a lower index of refraction than that of the pyroxene. Some of the jadeite crystals are colored green, as in the specimen just described (No. 43).

Number 16 is coarsely granular jadeite, apparently all the same mineral. Nothing but jadeite seems to be present.

Numbers 9, 24, 26, and 32 are alike in being very pure jadeite, almost entirely free from inclusions of other material. They consist of irregularly shaped anhedrons of colorless jadeite, varying in size from a diameter of one millimetre to minute microscopic grains. The grain is not uniform throughout the material, and in No. 24 there are prismatic forms and a somewhat parallel arrangement of the prisms. Pyroxene prismatic cleavage is pronounced, and extinction angles were measured as high as 32° and 40°. In No. 24 the cross-section of a microscopic prism shows the presence of the unit prism and orthopinacoid in nearly equal development. The cloudy-white color of the specimen is due to microscopic cracks and minute particles whose character is not determinable. In No. 9 there is a small amount of green mineral in fine-grained aggregation, somewhat fibrous. It is pleochroic from green to yellow, and has a lower refraction than jadeite. It is the same mineral that occurs in No. 20, which is amphibole nephrite.

Number 485 presents a somewhat laminated modification, in which the crystals of jadeite are all quite small, grading to microscopic; the longest crystal being about 0.8 millimetre. The lamination is due to the nearly parallel arrangement of some prisms, and to the alternation of layers of coarser and finer grains. The rock is very fresh and pure, without other constituent minerals, and there is little or no sign of decomposition or alteration by dynamic forces. Another section of No. 485 shows small aggregates of secondary inclusions as clouding in the centre of some of the crystals.

Numbers 42 and 490 are almost identical with the one last described (No. 485) in size of crystals, and to a less extent in the degree of lamination. There is a slight central clouding in some crystals, and a small amount of crushing. They are wholly jadeite without other minerals.

Number 497 is quite the same as the last specimens in size and aggregation of jadeite crystals, but there are scattered patches with very irregular outline of another mineral. The irregular outline is caused by the projection into this mineral of crystals of jadeite as though into a cavity. In some cases the rare mineral is crowded with minute crystals of jadeite. In each patch the mineral constitutes one individual with one orientation; sometimes two occur together. It is colorless, with much lower refraction than that of the pyroxene, and with moderate double refraction. The same mineral occurs in other specimens of jadeite rock. Its exact mineralogical nature was not made out, but it is probably albite.

Number 362 is quite the same in composition as the last, but the jadeite crystals are more lath-shaped, with jagged outline and somewhat parallel arrangement. In places they are very minute, and carry larger crystals of jadeite, with no optical distortion; that is, with evidence of having been strained. They are

clouded at the centre. Parts of the rock show signs of having been crushed and dragged. There is a very small amount of the colorless mineral, which is supposed to be albite.

Number 7 is a comparatively coarse-grained aggregation of jadeite crystals, the larger of which are 0.6 millimetre in diameter. The rock is colorless in thin section, with small spots of clouded material which is grayish-white in incident light. It is almost wholly jadeite, the clouded matter being indeterminable and presumably the beginnings of decomposition. The grains or anhedrons of jadeite are irregular in shape,—that is, allotriomorphic,—and are of various sizes. In some cases the prismatic cleavage is distinct. Areas that appear as one crystal often prove to be compounded of many individuals when seen between crossed nicols. The variations in grain and the curving of some cleavage lines, the mottling of the larger crystals when viewed between crossed nicols indicating strains and the first stages of granulation, together with the streaked arrangement of the smaller anhedrons, prove that the rock has been subject to forces that have crushed it to some extent. In places there are patches of a colorless mineral with lower index of refraction than that of jadeite, and with the double refraction and polysynthetic twinning of plagioclase feldspar. It acts as a matrix in which small prisms of jadeite lie at all positions, and against which the jadeite is automorphic. It exhibits no signs of alteration, whether of decomposition or of crushing. These facts point to its being of later origin than the dynamic metamorphism of the rock. But the areas of feldspar are so small that the evidence is not conclusive, and they may possibly have been formed when the jadeite crystallized. They certainly formed after the adjacent and enclosed jadeite crystallized. The feldspar probably has the composition $Ab_9\ An_1$; that is, oligoclase-albite.

A more fibrous modification of the jadeite is found in No. 44, which might almost be mistaken for fibrous amphibole. But some of the more compact crystals are seen in cross-section with pyroxenic prismatic cleavage, and the whole mass is clearly the same kind of mineral, having the same index of refraction. It appears as though rather large compact crystals of jadeite had been changed into groups of nearly parallel prisms of the same mineral. These are bent in various directions and grade into fine grains of jadeite. In this case, as in that of some of the coarse-grained rocks, dynamical action has changed the form of the pyroxene without altering its mineralogical character.

Number 51 is almost pure jadeite. In thin section the specimen is almost colorless, with a whitish tinge. It is traversed by numerous irregular cracks, as though the rock had been subjected to crushing. There are minute colorless veins crossing the section independent of the cracks. They are made up of larger crystals of the same mineral as the mass of the specimen. The whole is an aggregation of irregularly shaped crystals of jadeite. They do not exhibit crystallographic outlines, and vary in size, the majority being very minute. The substance of the jadeite is colorless and exhibits the usual cleavage and optical properties. There are scattered through it microscopically small opaque specks, usually with irregular outline, whose exact character is indeterminable. They are most probably magnetite. There are also small crystals of a colorless mineral, with index of refraction slightly higher than that of the surrounding jadeite, and having a double refraction about half as great as that of jadeite. Its outline in cross-section is square and eight-sided like that of a pyroxene. In longitudinal section it is rectangular, as though bounded by prism and basal plane. It appears to be either a tetragonal or orthorhombic mineral, having the axis of greatest elasticity parallel to the length of the prism. It is so filled with inclusions of jadeite that good interference figures were not obtained, hence its uniaxial or biaxial character could not be determined. It is therefore not possible to state its mineral character. The most probable assumption is that it is andalusite. Its quantity is not large, so that its presence does not materially affect the character of the rock, which is an almost pure jadeite.

Number 219 is an aggregate of small jadeite crystals with a few larger ones of irregular shape. The mass is streaked with greenish, dark-colored specks, which appear under the microscope as opaque particles crowded together in the larger jadeite crystals as products of alteration. Parts of the jadeite grains are colored pale green. In places the jadeite crystals are grouped in fan-like aggregates of radiating prisms. Cross-sections of these exhibit the characteristic prismatic cleavage. These crudely spherulitic aggregates occur in bands grading into small-grained layers. There are rather numerous patches of the colorless mineral (? albite), and somewhat lenticular crystals about 0.8 millimetre long, and smaller. They are strongly pleochroic with amphibole cleavage. Cross-sections show the orthopinacoid (100) strongly developed, besides the

unit prism faces (110). The colors are dark bluish-green to pale yellow. Longitudinal sections were not observed. The colors of this amphibole suggest an impure glaucophane.

Number 303 consists of irregularly shaped crystals of jadeite scattered through albite, which form interlocking crystals of variable size; some individuals enclosing a number of crystals of jadeite. The substance of albite is very pure and fresh, and exhibits a characteristic cleavage and optical properties. Twinning in polysynthetic lamellæ is developed to only a slight extent. Many crystals are not twinned. It would appear as though both minerals crystallized at one time. Their intimate association is interesting because of their chemical relation, jadeite being a metasilicate of alumina and soda, while albite is a polysilicate of alumina and soda. They might have formed from a mass too rich in silicate to form jadeite wholly, and too poor in silicate for albite to form singly.

Number 449 proves very clearly the origin of the fibrous amphibole or nephrite which constitutes the remaining thin sections which were studied microscopically. The same thing is shown by several other specimens, but this one is perhaps the most conclusive. In thin section No. 449 is a microcrystalline to microcryptocrystalline aggregation of colorless fibres and flakes or scales, having a confused arrangement, which in places approaches a more definite grouping, in which the fibres lie in several directions. In each of these directions the fibres are approximately parallel and slightly curving, so that streaks or bands of fibres extinguish the light synchronously between crossed nicols. The polarizing colors of these minute fibres are grays of the first order. They grade into thicker and more compact crystals with higher interference colors. These crystals exhibit distinct prismatic amphibole cleavage in cross-section, and are sometimes automorphic in the prism zone.

Through this mass are scattered fragmentary crystals of colorless jadeite, like that forming the rocks just described. It is distinguished from the amphibole by its higher refraction, appearing to rise considerably above the body of the rock. Its double refraction is also higher. Its prismatic cleavage is also characteristic. A lamellar twinning is present, and in places is curved and apparently the result of strain. Bordering and traversing the large jadeite crystals in seams is amphibole, sometimes oriented parallel to the jadeite, sometimes not. The amphibole is compact in some cases and fibrous in others. The transition is into compact amphibole, which frays out into curved fibres at the ends. It is evident that the fibrous amphibole composing this rock has been derived from colorless pyroxene or jadeite, remnants of which still exist in the rock. Another section of this rock shows the same microstructure, but none of the pyroxene remnants. Still another section of the same rock shows patches of fibres, most of which extinguish at nearly one time. These are banded by parallel lines of fibres with a different orientation. These patches represent the extent of jadeite crystals that were twinned in the usual manner, each crystal having been altered to a mass of amphibole fibres, most of which are parallel to one another, a part lying at various angles. The chemical analysis shows ten per centum of jadeite to have been present in the material analyzed.

In No. 18 the prisms are acicular and fibrous. There is more of an approach to streaked or parallel fibrous structure, though the needles cross one another at various angles. This structure is shown in the photomicrographs numbered 18 in Plates B and C. The amphibole has a pale-green color in thin section, the crystals being pleochroic,—yellowish-green parallel to the prism axis and bluish-green at nearly right angles. It is a mixture of jadeite and amphibole in the proportion of three to two, and consists of very minute fibres with a preponderating parallel arrangement, producing a more or less pronounced fibration or lamination in the rock. The chemical analysis shows that the specimen is a mixture of jadeite and amphibole rich in soda and magnesia.

A very good example of this alteration is shown in a thin section from No. 330, which has been photographed (Plate A). In the illustration the colorless jadeite appears dark, and the delicate twin striations are clearly seen. The jadeite in this rock is highly striated.

A precisely similar case is found in No. 601, which is a mass of microscopic to submicroscopic fibres of amphibole, with occasional larger compact crystals. Scattered through the mass are small fragments of colorless jadeite, as in the previous case. The alteration has gone farther, and only a little jadeite remains.

Another example of amphibole alteration is found in one thin section of No. 328. It is a confused aggregate of amphibole fibres, which, on account of the thickness of the rock sections, exhibit rather high inter-

ference colors. The index of refraction, however, is that of amphibole. There is a curved parting to the mass, and the appearance of rounded aggregates of colorless material in a gray matrix. This suggests the grain of the original pyroxene rock. A few fragments of colorless jadeite remain, as in No. 601. There are a few curved and distorted microscopic crystals of colorless mica or muscovite. The other section of No. 328 might be described as a jadeite consisting almost wholly of jadeite, with few individuals of a colorless indeterminable mineral.

Number 97 presents the same conditions as the foregoing. A few fragments of jadeite remain; the mass of the rock consisting of amphibole fibres, that in places reach the size of compact crystals.

Number 322 is the same, with a small amount of colorless jadeite in fan-shaped aggregates. These are shown in the photomicrograph (Plate A), the lighter gray portions being amphibole fibres.

Number 317 consists of minutely fibrous amphibole, and considerable compact amphibole in irregularly shaped crystals, in clusters and streaks through the rock. This is shown in the photomicrograph (Plate C). There are also remnants of small jadeite crystals in aggregations and streaks, and sometimes in spherulitic clusters, as in No. 322. The irregular and jagged outline of the pyroxene grains is exactly the same in both these thin sections.

Number 523 presents an instance in which the relation between the colorless pyroxene or jadeite and the equally colorless amphibole is not so evident. The rock consists of microscopic prisms and shorter crystals of pyroxene in an irregular aggregation, together with larger crystals of compact amphibole. The outline of the amphibole is determined by the adjacent pyroxene crystals. The two are distinguished by their optical characteristics and prismatic cleavage. The prisms of pyroxene are bounded in the prism zone by the faces of the unit prism, yielding nearly square cross-sections. The prisms penetrate the larger crystals of amphibole, and lie enclosed in them in all directions. In some cases the acicular prisms of pyroxene are located on both sides of a fracture line in the amphibole, or along the boundary between two amphibole crystals. The two minerals appear to be nearly contemporaneous crystallizations; the pyroxene being somewhat the earlier. The amphibole is not fibrous and does not seem to have resulted from the alteration of pyroxene. It is, however, quite the same in appearance as the compact amphibole, which is secondary. Its exact origin in this case is doubtful. The structure is very well shown in the photomicrograph (Plate B). The nearly square cross-section of pyroxene, the prismatic sections, and acicular crystals of the same mineral can be seen in the broader areas of the compact amphibole. In places there is a green color which occurs both in the jadeite and the amphibole. They are slightly pleochroic, as in other cases already noted.

The microstructure of No. 581 is clearly the result of amphibolic alteration of jadeite. The rock consists of microcrystalline to microcryptocrystalline aggregation of fibres of colorless amphibole that extinguish light between crossed nicols in irregular patches, some of which are banded in parallel lines. These patches correspond to the originally twinned pyroxene. In places the amphibole is in compact crystals. There is a curved fibration in one direction through the rock, along which it has cracked. A few small clouded spots appear to be impure muscovite. The rock is a nephrite.

This is also the microstructure of No. 351, except that the patches are larger, showing that the original rock was a coarser-grained jadeite. There is also a mottling similar in size to that noticed in the large crystals of jadeite, where it was the result of strain (compare with jadeite No. 496). This and all of the succeeding specimens are nephrite.

Number 81 has exactly the same microstructure and composition as No. 351.

The same is true of No. 630. The once coarse-grained aggregate of pyroxene crystals is perfectly mapped out by the patches of similarly oriented amphibole fibres arranged in a direction corresponding to the twinned positions of the pyroxene lamellæ.

Number 96 shows the same structure on a larger scale. There are similar mottled patches. But the mottling is so coarse that the details of its structure can be seen. It consists of fan-like bundles of fibres crossing one another in two or more directions, sometimes producing spherulitic aggregates, with four long arms. In other places the fibres are arranged in lines of lenticular or spindle-shaped bundles, which produce curving lines. Between the latter are fibres in other orientations, probably bundles seen in cross-section.

No. 71 B
Nephrite
Turkistan

No. 71 C
Nephrite
Turkistan

No. 71 A
Nephrite
Turkistan

No. 141
Nephrite
Jordansmühl, Silesia

No. 18 A
Jadeite
Burma

No. 523
Jadeite
China (?)

MICROSECTIONS

This appears to be the same structure that produces the mottling in the finer-grained forms, but it is not so easily analyzed in those cases, because of the difficulty of getting sections thin enough.

Number 84 is the same as No. 630 in all respects. In one place there is a banding of the fibres as though there had been a dragging of the material in that direction.

The long streaks of parallel fibres are more marked in No. 104, which is otherwise like the previous sections. Its microstructure is shown in the photomicrograph (Plate C).

A transition from the patchy structure shown by the last few sections into a uniform aggregation of minute fibres is seen in No. 443. The two structures are parts of the same rock. In the finer-grained portion are groups of compact amphiboles yielding fan-shaped sections.

Number 331 belongs to this class of rocks, and is nearly identical with those just described, except that there are areas of fibres that are almost wholly parallel, so that they approach closely to compact amphibole. This structure is shown in the photomicrograph (Plate C).

Numbers 20 and 22 are nephrite with an intense emerald-green mineral in irregular patches and spots. The sections differ somewhat in texture. No. 20 consists of bladed, prismatic, and irregularly shaped anhedrons, in places with parallel arrangement. Some crystals are colorless, others pale green, others intense brilliant green. In size they vary from anhedrons about one millimetre in diameter to microscopically minute particles. The more strongly colored crystals have higher refraction, and in places exhibit aggregate polarization. The colors of the different crystals vary in shade, but are of like tone, with marked pleochroism from emerald-green to greenish-yellow and yellow. The paler crystals are undoubtedly amphibole, as is shown by the prismatic cleavage. But the strongly colored mineral differs somewhat optically from most amphiboles; however, it is referred to amphibole provisionally, and may be a variety not yet described. No. 22 contains more colorless amphibole. Before the blowpipe both specimens gave reactions for chromium.

The remaining thin sections of nephrite exhibit many instances of exactly similar microstructure and of identical mineral composition. They may be described in groups, which differ from one another only in slight modifications in the arrangement of the amphibole fibres. In all of them there is little or no trace of the original granular pyroxene rock. But all the structures have been observed in direct connection with others that exhibit the evidence of their origin, or that still contain fragments of pyroxene. So that it is reasonable to assume that all of the nephrite studied in this Collection has been formed by the amphibolical alteration of colorless pyroxene or jadeite.

In the following thin sections—Nos. 82, 83, 99, 198, 234, 280, 299, 401, 648—there is sometimes a faint suggestion of the patches derived from previous pyroxene, but the amphibole fibres are in a confused aggregation, with occasionally longer streaks of nearly parallel fibres. In the case of No. 198 there is a yellowish stain in part of the section, which seems to be occasioned by hydrous oxide of iron. A brown mineral in another part of the same section is in thin plates, not definitely bounded by crystallographic planes. Its exact nature is uncertain, but it suggests brown mica.

Numbers 82 and 99, although differing in color in the specimens, are closely alike in thin section. The texture in the large green slab (No. 99) varies from place to place, which may be seen on the back of the specimen; hence thin sections will vary according to the place from which they were cut. Some of it is extremely fine-grained; in places it is in patches of coarser grain. The two specimens consist of the same mineral and have almost identical specific gravity. Under the microscope the thin sections are also alike in being made up of minute scales and fibres of nephrite, through which are scattered, in No. 99, patches consisting of parallel fibres, sometimes curved, of the same mineral, nephrite; while in No. 82 there are occasional patches consisting of compact nephrite, not fibrous. The difference is slight and would not show in the specimen.

Number 80 is one of this kind with rather more parallelism to the fibres in places, and with traces of the original pyroxenic grains in the arrangement of the fibres. Prismatic crystals of amphibole are more abundant. They lie in several directions. Sometimes a number close to one another will have parallel orientations which are shown by the exact parallelism of a group of cross-sections of amphibole prisms.

Number 531 is similar to the one last mentioned.

The following thin sections—Nos. 120, 289, 336, 648, 765—are alike in having a microstructure caused

by a nearly uniform mixture of amphibole fibres, which are in fan-shaped divergent clusters, sometimes approaching a spherulitic arrangement. No. 648 carries a few microscopic flakes of colorless mica.

In No. 71 some of the bundles of fibres are longer and larger, and needles of compact amphibole are sparingly present. Three photomicrographs, Nos. 71*a*, *b*, and *c* on Plate B, were made from thin sections of this specimen. The bundles of fibres have several orientations, which can be seen in the illustrations.

In No. 141 the compact prisms of amphibole are much more numerous, and give the rock a more distinctly marked microstructure, which is well shown in photomicrograph (Plate B). The prisms grade into fibres, are in nearly parallel groups, and cross one another in several directions.

The following thin sections are nephrites consisting of very minute fibres with a preponderating parallel arrangement, producing more or less fibration or lamination in the rock:

In Nos. 89, 92, and 205 the delicate fibres are curved in several directions or extinguish light in irregular patches. There is a yellowish-brown tabular mineral, with six sides to some crystals. The same substance also occurs in minute particles. It appears to be a hydrous oxide of iron.

Number 281 is one of this class of rocks, with somewhat larger fibres. There are numerous crooked cracks parallel to the direction of fibration.

Number 286 consists of very minute fibres and particles, with banded structure shown in photomicrograph (Plate C); some bands being clouded, others transparent. There are small opaque spots that are light green by incident light, and irregularly shaped crystals of a reddish-brown isotropic mineral, which is surrounded by a white opaque substance resembling leucoxene. It is probably perovskite.

Number 153 is nephrite in an aggregation of extremely fine fibres that lie parallel to one another and have been bent into contorted and crenulated bands. There is some clouding of the material, which is white by incident light and yellowish by transmitted light. In places the fibres are less crinkled and the substance is nearly transparent, and the double refraction is more uniform as shown by the interference colors, but there is some mottling. Throughout much of the section there is aggregate polarization indicating very minute confused fibres. The thin section cut across the fibres exhibits less crinkling and a less fibrous texture, and indicates that the fibres are flattened or bladed. The nephrite is very free from inclusions of other minerals, and, as shown by the chemical analysis, is very pure nephrite, having the composition of tremolite with less than four per centum of ferrous oxide.

Numbers 59, 159, 160, 162, 182, 183, and 283 have the fibres in parallel, and sometimes in curved arrangement, with a parallel or laminated structure strongly marked and accompanied by crooked cracks in most cases. The rock appears to have been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism.

Number 155 is nephrite, consisting of confused fibres of amphibole, extremely minute, in some places crinkled and contorted, in other places in streaks of parallel fibres. It is traversed by short crooked cracks containing dark coloring matter. The nephrite is stained yellow with streaks of brown. The fibres are so minute that they overlie one another in the thin section and produce aggregate polarizations between crossed nicols.

The most extreme case of this kind is found in No. 180; the fibres are almost perfectly parallel, with striations that seem to be due to twinning parallel to the orthopinacoid. The structure resembles that of silicified wood in longitudinal section, and is shown in the photomicrograph (Plate C).

Three specimens remain to be described which differ slightly from those already treated, but which are nephrite or jadeite with other minerals in variable quantities:

Number 177 is a jadeite, composed of very small, irregularly shaped crystals or grains of colorless jadeite and pale-green amphibole. These have a crudely parallel orientation, producing a lamination or fibration of the mass, which is further emphasized by streaks of minute grains of an almost colorless mineral with high index of refraction and high double refraction. Some crystals of it are well developed and sharply defined, and appear in quadratic or tetragonal pyramids, with very short prisms in some cases. These characteristics are those of zircon, but its determination is questionable. There is also a little iron oxide, probably magnetite, in irregularly shaped grains associated with the zircon. The green color of the amphibole is quite

pronounced in some crystals, and in one instance is strong blue-green. The chemical analysis shows that the specimen consists of jadeite with sixteen per centum of nephrite.

Number 172 is a rock of quite different composition, although consisting mainly of amphibole. The amphibole is in minute, irregularly shaped crystals, and some larger ones that exhibit distinct green color, with pleochroism from yellowish- to bluish-green. In places the green amphibole occurs in distinct prismatic crystals, with the prism faces and cleavage well developed. Between these minute crystals is a colorless mineral, with lower refraction and low double refraction, of very pure substance suggesting quartz. It is wholly allotriomorphic, or interstitial, acting as a cement for the other minerals. Though in very small areas, it is very widely scattered through the rock, and is present in considerable amount for an accessory mineral. Scattered through the rock in much greater quantity are small particles of an almost colorless mineral whose form and optical properties correspond to those of clinozoisite. It constitutes about forty per centum of the rock. With it is associated a small amount of epidote, distinguished by its yellow color in thin sections. There are small, irregularly shaped grains of highly refracting yellowish mineral, possibly titanite, with attached grains of magnetite. There are a few small crystals of colorless garnet.

Number 188 is a fine-grained aggregate of colorless to pale-green jadeite crystals with a curving parallel arrangement of the more or less prismatic crystals. There are abundant colorless garnets about 0.15 to 0.30 millimetre in diameter, without distinct crystal outline. There is a subordinate amount of colorless mica-like mineral with the optical properties of pennine or clinochlore. There are also numerous minute grains of a yellow mineral with high refraction, which is probably sphene. The structure of this rock is shown in the photomicrograph (Plate A), taken between crossed nicols. Consequently the garnets appear as black spots.

Since the above was written a number of thin sections of European, Siberian, and Turkistan material have been examined. The three thin sections Nos. 135, 138, and 140, representing nephrite from Jordansmühl, Silesia, are almost identical. They consist of nephrite in fibres, flakes, and bladed crystals irregularly aggregated with larger crystals; in some cases broad and grading into the fibrous forms; in others, long acicular prisms. All are the same kind of amphibole. Cross-sections of prisms show the characteristic amphibole cleavage, and prismatic faces modified by orthopinacoid and less pronounced clinopinacoid. There is a small amount of an opaque, black mineral, probably magnetite, also minute, microscopic brown particles included in the larger amphiboles. Another thin section of Jordansmühl material (134*a*) is fibrous nephrite with very fine texture. There are occasional small areas of a colorless mineral, apparently fibrous or in minute scales, having larger refraction than nephrite, about the same double refraction as quartz, possibly a little higher. It appears nearly uniaxial in some cases and distinctly biaxial in others, is optically positive, and is probably a chloritic mineral, most likely clinochlore. There are also occasional spots formed of a cloud of opaque dot-like particles and some that are possibly magnetite. In thin sections of No. 134*c* the rock is transparent, and is seen to consist of an aggregation of microscopic scales and fibres in all positions. A few larger patches of the same are also seen, and some scattered acicular crystals of colorless amphibole (nephrite), with characteristic cross-section and prismatic cleavage. The refraction of all these forms of amphibole is alike. No chromite occurs in the sections.

The three sections of nephrite from Reichenstein (Nos. 144, 146, 147) are of very simple character. No. 146 consists of a fine-grained aggregation of minute anhedrons of amphibole with scattered microscopic grains of arsenopyrite. No. 147 is composed of more fibrous amphibole with schistose structure and considerable arsenopyrite in lenticular masses. No. 144 is an extremely fine fibrous and scaly aggregate of amphibole.

Number 148, the Schwemsal nephrite, consists of minute flakes and fibres of amphibole in spherulitic bundles and patches.

Four specimens from Siberia (Nos. 123, 124, 125, 130) are alike in being nephrite. In thin section they are nearly colorless to pale green. No. 124 is mottled with grayish spots and is traversed by irregularly curved and sometimes fan-shaped cracks. There are a few opaque black spots. The gray spots are cross-sections of amphibole crystals and prisms, exhibiting the characteristic cleavage. The texture is not uniform, consisting of radiating bundles of amphibole prisms and blades and a finer felt of the same mineral.

No. 125 is stained in places orange-yellow. The texture is that of a fine felt of amphibole scales and blades, through which are scattered acicular crystals and curved prisms of colorless amphibole. These are often cracked across the prisms. The yellow staining appears to be a submicroscopic pigment. No. 123 consists of a fine felt of amphibole with streaks and patches of blades and bundles of somewhat larger crystals of the same mineral.

Number 130 furnishes two sections with slightly different characters. One is a fine felt of amphibole flakes with coarser fan-like and felt-like aggregations of a micaceous mineral having the optical properties of a colorless chlorite, probably a variety of clinochlore, like that found in the Jordansmühl specimen No. 134*a*. The other section does not exhibit any of the chloritic mineral, but is a fine felt of amphibole with bundles of larger amphibole blades and crystals.

Seven specimens of material from Chinese Turkistan (Nos. 66*e*, 66*n*, 67, 68, 73, 78, 79) are also nephrite. No. 78 is a fine-grained felt of scales and fibres with streaks or veins of larger blades and crystals, nearly parallel to one another, lying across the veins. There are minute areas and streaks of the colorless clinochlore. There are besides a few opaque grains of a mineral dark reddish-brown in thin edges. The grains are much cracked and traversed by amphibole. The mineral may be chromite, traces of chromium being found upon analysis. No. 68 shows signs of a former coarse-grained rock, presumably jadeite, from which the nephrite has been derived. Minute scales and fibres of amphibole are nearly parallel throughout areas corresponding to spaces once occupied by some coarse-grained aggregation of minerals. This produces a mottled appearance in the section because of the diverse orientation of the different areas of parallel scales. There are a few compact crystals of larger size scattered through the mass. No. 67 has an irregular texture, mostly extremely fine-grained, microcrystalline to microcryptocrystalline. In places there is spherulitic fibrous texture in areas suggesting former coarse-grained rock. There are a few small crystals of muscovite, with bent laminæ having fibrous edges and intercalated lenses of amphibole. There are some apatite crystals cracked and traversed by amphibole. Both the muscovite and apatite appear to be remnants of a rock metamorphosed to nephrite. Patches with yellowish to opaque grains of highly refracting mineral are indeterminable. No. 79 is a fine felt of minute scales, some small patches with nearly parallel fibres suggesting former jadeite crystals. Numerous opaque microscopic crystals are arranged in streaks to some extent, and have a yellowish metallic lustre in sunlight. Their form appears to be orthorhombic, and they may be marcasite or arsenopyrite. No. 73 has a somewhat variable texture: a fine felt of amphibole, with irregularly shaped areas in which the fibres have nearly parallel orientation. There is some cracked opaque mineral surrounded by a narrow zone of colorless clinochlore.

Number 66*e* is nephrite composed of minute scales and fibres of colorless amphibole exhibiting areas with nearly parallel orientation of scales, suggesting the position of former pyroxene crystals from which the nephrite was formed. There are scattered small bundles of colorless amphibole fibres, relatively long and delicate (asbestiform). In some cases the fibres cross one another in several directions, in others they form fan-shaped bundles.

Number 66*n* is similar in its microscopical texture, being composed of scales or fibres of amphibole showing by areas of nearly parallelly oriented scales the position of former pyroxene crystals, the original rock having been a relatively coarse-grained one. The former grains of pyroxene are also indicated by slight differences in the amount of minute dust-like particles in different areas. Along the edge of one of the sections there is some yellow coloring or staining, as there is in one of the sections of No. 66*e*, produced by minutely dendritic cloudy matter, the outline of the component parts of which is not distinguishable. It does not appreciably affect the optical behavior of the nephrite scales or fibres which it colors.

TENACITY

The great tenacity of jade has long been known as perhaps its most characteristic property. Lapidaries who are familiar with the jade group of minerals state that it requires several times more time to cut or carve a piece of jadeite or nephrite than it does to cut or carve a similar object from rock-crystal or agate,

No. 317
Nephrite
China (?)

No. 331
Nephrite
China (?)

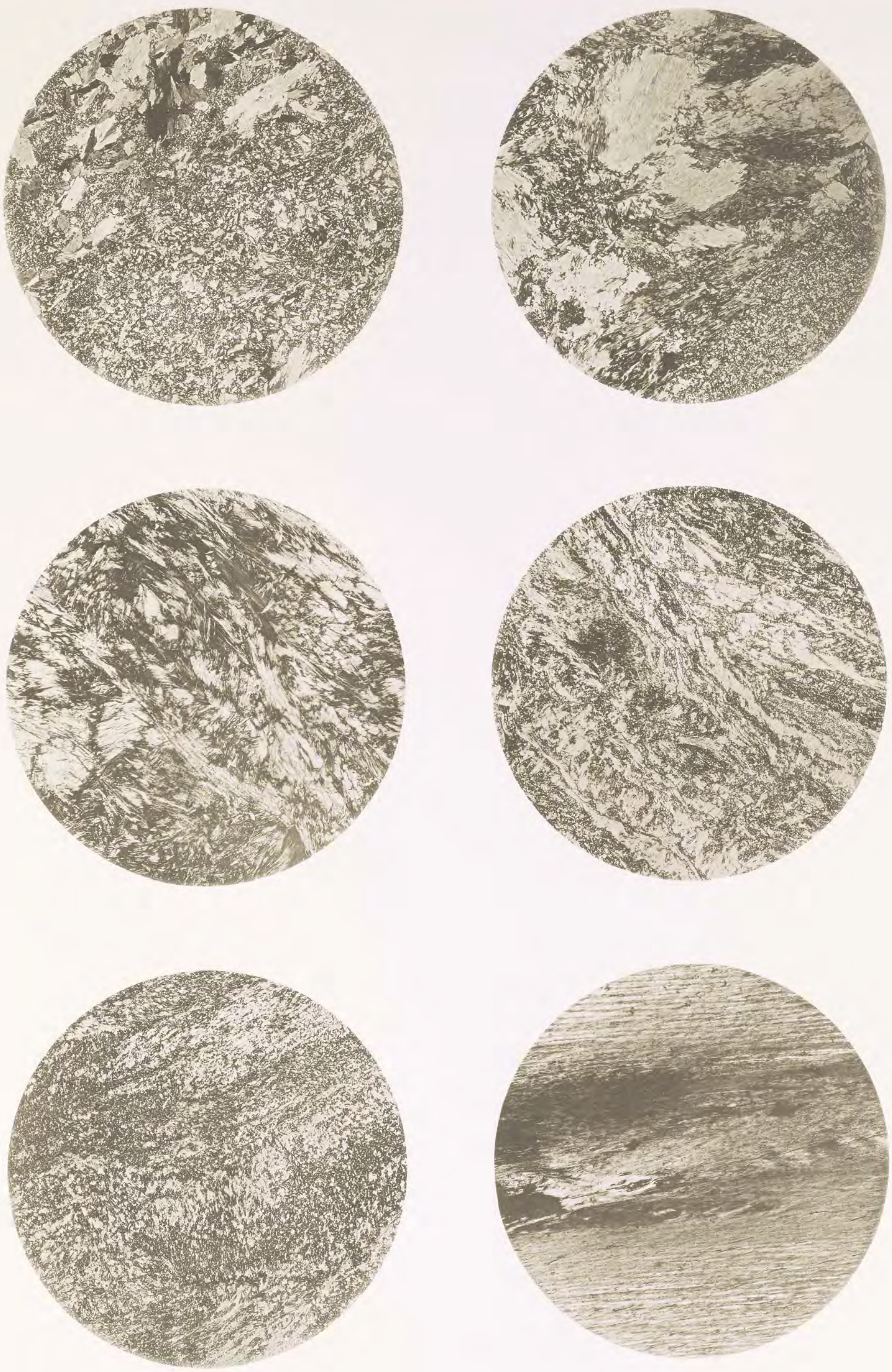
No. 18 B
Jadeite
Burma

No. 286
Nephrite
New Zealand

No. 104
Nephrite
Siberia

No. 180
Nephrite
Lake Neuchâtel, Switzerland

MICROSECTIONS



both harder than the nephrite form of jade; and its resistance to blows and pressure has frequently been proved by direct experiment. It is said that a stone battle-axe brought back by Columbus, when tried by Peter Martyr on a piece of iron, cut into the metal without injuring the stone.[1] It is not definitely stated that the axe was of jade, but the results fit in well with the later and better authenticated experiments.

In 1860 Krantz, the mineral-dealer of Bonn, having attempted unsuccessfully to break a large block with a sledge-hammer, sent it to the Krupp Gun Works at Essen, where it was placed under a steam-hammer to be broken. The anvil on which it was placed was ruined, while the mass of nephrite remained unhurt. Later, the block was broken into many fragments by heating it to redness and then throwing it into water.

A more scientific experiment was that made by Von Schlagintweit, the great Asiatic explorer, who has made us so familiar with jade and its occurrences in Chinese Turkistan. He selected a fine light-colored specimen of the best quality of nephrite, seventy cubic centimetres in volume, with two flat fracture faces. This was placed on an anvil within an upright tube, and on the exposed face of the specimen was placed a steel chisel, edge down, the blade measuring 2.5 centimetres by 0.1 millimetre thick. A cylindrical mass of iron weighing fifty kilogrammes was then allowed to fall upon the upper end of the chisel, through a distance of thirty-five centimetres. Under this test the tenacity of the mineral was found to be so great that the edge of the chisel was turned, and a metallic mark resembling a wide lead-pencil mark was left on the surface of the nephrite, which was uninjured except that on the under side of the specimen, where it had rested on the anvil, three small initial protuberances had been somewhat bruised by the blow, as indicated by three white spots.

In 1898 Professor Jaczewsky, who had discovered great beds of nephrite in Siberia (described by him in a later section of this work), made some preliminary tests which he kindly communicated to us. Two cubes of different kinds of Siberian nephrite were cut and submitted to a crushing test in the big Werder machine in the laboratory of the School of Bridges and Highways of Emperor Alexander I, at St. Petersburg, under the supervision of Mr. B. Vassenko. The results are here given:

Number 1. Specific gravity 3.003, green nephrite, somewhat transparent at the edges, and showing traces of fissuration on its polished surface, was crushed under a pressure of 4222 kilogrammes to the square centimetre = 60,050 pounds per square inch.

Number 2. A perfectly black nephrite without fissures, specific gravity 2.993, failed under a pressure of 7759 kilogrammes to the square centimetre = 110,000 pounds per square inch.

Both broke with a sharp report.

In order to obtain the most scientific results in regard to the strength of both minerals, Mr. Bishop decided to sacrifice sufficient material for three series of resistance tests that should be, as far as possible, both exhaustive and authoritative. These were:

Resistance to impact,
Resistance to compression, and
Resistance to tension.

The impact experiments were conducted at the Engineering Laboratory of Harvard University, by Mr. Logan Waller Page, of the Engineering Laboratory of Harvard University, now expert in charge of the Laboratory of Physical Tests, Division of Chemistry, Department of Agriculture, Washington, D. C., and were made on half-inch cubes of carefully selected typical material from different localities:

(1) Number 7. Jadeite from Burma; specific gravity, 3.3122; hardness, 7; color, light gray, with occasional green spots; remarkably homogeneous and compact.

(2) Number 96. Nephrite boulder from China (probably of Turkistan origin); specific gravity, 2.9690; hardness, 6.5; color, sage-green, apparently very compact, with a few spots of what seemed to be manganous oxide.

[1] Bastian, Culturlander des alten Amerika, 1878, I. 592, quoted in Meyer's Jadeit und Nephrit Objecte, II. 2.

(3) Number 162. Nephrite boulder from the Middle Island, New Zealand; specific gravity, 3.1022; hardness, 6.5; color, rich dark green.

(4) Number 134*a*. Nephrite from Jordansmühl, Silesia; specific gravity, 2.9040; hardness, 6.5; color, impure gray mottled with dark green, almost black; splintery, horny structure.

(5) Number 130. Nephrite from Siberia; specific gravity, 2.9758; hardness, 6.5; color, dark olive-green with a patch of very light green and dark, almost black, irregular veinings; fracture splintery.

(6) Number 78. Nephrite from Chinese Turkistan; specific gravity, 2.9832; hardness, 6.5; color, sage-green with minute black specks; translucent, homogeneous, and compact, showing on the exterior reflections of sinewy veinings.

(7) Number 67. Nephrite from Chinese Turkistan; specific gravity, 2.9102; hardness, 6.5; color, white with light-greenish tint; tough, horny texture.

(8) Number 79. Nephrite from Chinese Turkistan; specific gravity, 2.9168; hardness, 6.5; color, very dark gray, almost black; homogeneous and compact.

His report is as follows:

IMPACT TESTS ON JADE

In finding out the possible range of the application and usefulness of any material in the arts, among the qualities most important to be determined is its power of resisting blows, or impact. The momentary stresses set up as a result of a blow will vary with the precise form of the stressed body and with the method of application of the blow. If the body is a right prism or cylinder, and is supported at the bottom, and the effect of the blow is distributed evenly over the whole of the upper surface, the stresses set up will be purely compressive, of course, with the exception of the accompanying shearing stresses along planes inclined to the ends. If such a body is supported on top, and the blow coming above is resisted by a yoke attached to the lower end of the body, the stresses set up will be chiefly tensile. If the body be in the form of a beam, and the blow applied anywhere between the two supports, there will be compressive, tensile, and shearing stresses. It is therefore necessary, in testing the resistance to impact offered by a body, to specify exactly the conditions under which the test is conducted.

The standard impact test adopted in the engineering laboratory of Harvard University subjects the material to be tested to blows from a falling hammer, through an intervening plunger. The power of resisting such treatment—that is, of sustaining it without fracture—is evidence of a property which may be called "toughness." This term is not altogether satisfactory, for since there are two ways in which a body subjected to impact may resist fracture, there are two ways in which it may be interpreted. It may be a malleable material capable of considerable plastic or permanent deformation (as, for example, lead or copper), in which case the energy of the blow is used up in permanently deforming it. Or it may be a substance which permits a large elastic deformation, and has a high elastic limit; in which case considerable energy will be required to stress the material to that elastic limit. A material of this latter class, which is also capable of but slight or no permanent deformation, is commonly called a brittle material.

Jade appears to belong to the class of brittle substances which permit of no plastic deformation, and which consequently fracture when stressed to the elastic limit. The resistance to fracture offered by a cube of such a material is proportional to the maximum compressive stress and also to the accompanying deflection. For such a material an expression for the resistance to impact can be readily found.

Let R be the energy of the blow causing fracture,
E the modulus of elasticity of the material,
P the stress at the elastic limit, which is also the maximum compressive stress,
d the strain at the elastic limit,
K some constant,

Then $R=KPd$,

But $E=\frac{P}{d}$

Therefore $R=\frac{P^2}{E}$

—that is to say, the power of resisting impact is proportional to the square of the ultimate compressive stress, and inversely as the modulus of elasticity of the material. This assumes that the blow is evenly distributed over the top surface of the test specimen. In actual practice, however, such ideal conditions are almost impossible to bring about; and if this is not the case, the blow will be received and its effect concentrated on a few high points on the receiv-

ing surface, with the result that the material will be unequally stressed in its different parts, and will break down locally at the high points. As this would give conditions that could not be repeated at will, it is considered undesirable to attempt to get uniform distribution of the stress, and an intentional concentration at the centre of the upper surface has been substituted. To effect this concentration an intervening plunger is used, the lower and bearing surface of which is spherical. The stresses set up in the material as the result of a blow delivered through such a plunger are undoubtedly more complex than would be the case with a flat-end hammer or plunger; but as the object of the test is not to obtain physical constants, but to find comparative powers of resisting impact, that consideration is of small account compared with the advantage of uniformity of conditions during the standard test.

These tests were made in the engineering laboratory of Harvard University. The machine used was one designed by the writer, which consists of a one-kilogramme hammer guided by two vertical rods. The hammer is raised by a screw, and can be dropped automatically from any desired height, and it falls on a plunger which rests on the test-cube. The lower and bearing surface of the plunger is spherical in shape, having a radius of one centimetre. The test-cube is adjusted so that the centre of its upper surface is tangent to the spherical end of the plunger, and the plunger is pressed firmly upon the cube by two spiral springs. The plunger is made of a very hard variety of steel, and its spherical end is tempered in the same manner as the point of an armor-piercing projectile, and it is bolted to a cross-head which is free to slide on two vertical guide-rods. The test-cube is held on the base of the machine by a device which prevents its moving when a blow is struck by the hammer, but in no way strengthens it. A small lever carrying a brass pencil at its free end is connected with the side of the cross-head by a link-motion, arranged so that it gives a vertical movement to the pencil five times as great as the movement of the cross-head. The pencil presses against a drum, and its movement is recorded on a slip of silicated paper fastened thereon, and the drum is turned automatically through a small angle at each stroke of the hammer. In this way a record is obtained of the movement of the plunger at each blow of the hammer.

When the hammer strikes the plunger, if the blow is within the elastic limit of the test-cube beneath it, the plunger recovers; if, however, the elastic limit is passed, the plunger stays at the point to which it is driven, and an automatic record is obtained on the drum showing the behavior of the test-cube at each blow. The number of blows required to destroy a test-cube is generally used as a measure of its power of resisting impact, but the energy in centimetre-grammes of the destroying blow, or the total energy expended, does equally well.

In the present tests twenty-two half-inch cubes of jade were employed, four from Burma, two from China, one from New Zealand, three from Jordansmühl, Silesia, three from Siberia, and nine of three distinct varieties from Turkistan. The method adopted for testing these cubes consisted of a one-centimetre fall of the hammer for the first blow, and an increased fall of one centimetre for each succeeding blow until the cube was destroyed.

Before testing the jade several trial tests were made to ascertain if the machine was in thorough working order. The material selected for this purpose was a highly metamorphic silicious slate, which was exceedingly hard. This particular rock was taken at the suggestion of an eminent petrographical authority, who expressed the opinion that it would stand a higher impact test than jade, an opinion in which the writer fully concurred. The four samples tested stood on the average sixteen blows, or a breaking blow of 16,000 centimetre-grammes of energy; the total amount of energy expended on each cube was 136,000 centimetre-grammes.

The twenty-two cubes were tested in the following order: The four of Burmese jadeite (No. 7); the two of nephrite from a boulder from China (No. 96); the one of nephrite from New Zealand (No. 162); the three of Jordansmühl nephrite (No. 134*a*); the three of Siberian nephrite (No. 130); the three of nephrite of dark sage-green color from Turkistan (No. 78); the three of nephrite white in color from Turkistan (No. 67); and the three of nephrite of very dark-gray color from Turkistan (No. 79).

The results of these tests are given below, and numbered in the order in which they were made. The height given for each cube is the average of five measurements taken on separate points between the load surfaces.

TESTS ON BURMESE JADEITE (No. 7)

Test No. 1. This cube was of a light sea-green color. The load was applied at right angles to the striation and cleavage cracks, which, though very apparent, were not so numerous as in some of the other specimens. There were also a few flaws visible, though probably of insufficient size to weaken the specimen to any degree. The height of this cube was 0.506 of an inch. Just one hundred blows were required to break this cube, or a final blow of 100,000 centimetre-grammes; the total energy expended was 5,050,000 centimetre-grammes.

Test No. 2. This cube was similar in color and appearance to No. 1. The load was applied parallel to the striation and cleavage; the latter being almost invisible. The height of the cube was 0.5004 of an inch. It stood one hundred and three blows, or a final blow of 103,000 centimetre-grammes; the total energy expended was 5,356,000 centimetre-grammes.

Test No. 3. This cube was of a very much lighter green color than the other two. It contained numerous cleavage cracks, some of considerable size, parallel to the striation, which was slight. Its height was 0.584 of an inch. The load was applied parallel to the cleavage. It stood one hundred and twelve blows, or a final blow of 112,000 centimetre-grammes; the total energy applied was 6,328,000 centimetre-grammes.

Test No. 4. This cube was also of a light-green color. The striation was very slight, and there was almost an absence of cleavage cracks. Its height was 0.503 of an inch. The load was applied almost at right angles to the striation and cleavage. It stood one hundred and thirty-one blows, or a final blow of 131,000 centimetre-grammes; the total energy expended was 8,646,000 centimetre-grammes.

TESTS ON CHINESE (TURKISTAN) NEPHRITE (No. 96)

Test No. 5. This cube was of a greenish-gray color. There was very little striation, but cleavage cracks were apparent. Its height was 0.510 of an inch. The load was applied at right angles to the cleavage. It stood eighty-one blows, or a final blow of 81,000 centimetre-grammes; the total energy expended was 3,321,000 centimetre-grammes.

Test No. 6. This cube was also of a greenish-gray color. Cleavage cracks were apparent, but striation was scarcely visible. Its height was 0.511 of an inch. The load was applied at right angles to the cleavage. It stood thirty-nine blows, or a final blow of 39,000 centimetre-grammes; the total energy expended was 780,000 centimetre-grammes.

TEST ON NEW ZEALAND NEPHRITE (No. 162)

Test No. 7. This cube was of a very dark-green color. There was no striation visible in this cube and only one cleavage crack, to which the load was applied at right angles. Its height was 0.496 of an inch. It stood eighty-five blows, or a final blow of 85,000 centimetre-grammes; the total energy expended was 3,655,000 centimetre-grammes.

TESTS ON JORDANSMÜHL NEPHRITE (No. 134*a*)

Test No. 8. Color, impure gray and pale green with dark-green spots and patches. The striation in this cube was very slight, and there were no cleavage cracks. The load was applied parallel to the striation. Its height was 0.500 of an inch. It stood thirty-two blows, or a final blow of 32,000 centimetre-grammes; the total energy expended was 528,000 centimetre-grammes.

Test No. 9. The color of this cube was the same as that of No. 8. Only slight striation, to which the load was applied at an angle of about 45°. Its height was 0.494 of an inch. It stood thirty-nine blows, or a final blow of 39,000 centimetre-grammes; the total energy expended was 780,000 centimetre-grammes.

100

No. 680

SACRIFICIAL TRIPOD

(San Hsi Ting)

Ch'ien-lung (1736–95)

Nephrite

Test No. 10. This cube was of the same color as the other two. There was only slight striation, to which the load was applied at right angles. Its height was 0.485 of an inch. It stood thirty-seven blows, or a final blow of 37,000 centimetre-grammes; the total energy expended was 703,000 centimetre-grammes.

TESTS ON SIBERIAN NEPHRITE (No. 130)

Test No. 11. Of a dark olive-green color. There were only a very few slight cleavage cracks in this cube, to which the load was applied parallel. Its height was 0.503 of an inch. It stood thirty-two blows, or a final blow of 32,000 centimetre-grammes; the total energy expended was 528,000 centimetre-grammes.

Test No. 12. This cube was also of a dark olive-green color, and its cleavage very slight. The load was applied at an angle of about 40° to the cleavage. Its height was 0.466 of an inch. It stood forty-eight blows, or a final blow of 48,000 centimetre-grammes; the total energy expended was 1,176,000 centimetre-grammes.

Test No. 13. This cube was of a similar color to the other two. Its cleavage was very indistinct, and the load was applied at an angle of about 45°. On account of the direction in which these cubes were cut, it was impossible to apply the load at right angles to any of them. Its height was 0.492 of an inch. It stood forty-eight blows, or a final blow of 48,000 centimetre-grammes; the total energy expended was 1,176,000 centimetre-grammes.

TESTS ON TURKISTAN NEPHRITE (No. 78)

Test No. 14. Of a dark sage-green color. There were no traces visible either of cleavage or striation in this cube. Height of cube, 0.515 of an inch. It stood sixty-eight blows, or a final blow of 68,000 centimetre-grammes; the total energy expended was 2,346,000 centimetre-grammes.

Test No. 15. This cube was of a dark sage-green color, and slightly striated. The load was applied almost parallel to the striation. Its height was 0.518 of an inch. It stood seventy-six blows, or a final blow of 76,000 centimetre-grammes; the total energy expended was 2,926,000 centimetre-grammes.

Test No. 16. Of a dark sage-green color, and slightly striated; there was also a slight flaw. The load was applied at right angles to the striation. Height of cube, 0.517 of an inch. It stood eighty-two blows, or a final blow of 82,000 centimetre-grammes; the total energy expended was 3,403,000 centimetre-grammes.

TESTS ON TURKISTAN NEPHRITE (No. 67)

Test No. 17. All three of these cubes were white with a slight tint, and there was no trace of cleavage or striation visible in them. The height of this cube was 0.482 of an inch. It stood forty-one blows, or a final blow of 41,000 centimetre-grammes; the total energy expended was 861,000 centimetre-grammes.

Test No. 18. The height of this cube was 0.501 of an inch. It stood thirty-two blows, or a final blow of 32,000 centimetre-grammes; the total energy expended was 528,000 centimetre-grammes.

Test No. 19. The height of this cube was 0.500 of an inch. It stood thirty-eight blows, or a final blow of 38,000 centimetre-grammes; the total energy expended was 741,000 centimetre-grammes.

TESTS ON TURKISTAN NEPHRITE (No. 79)

Test No. 20. Of a very dark-gray color. Striation was distinct, to which the load was applied at right angles. The height of this cube was 0.513 of an inch. It stood one hundred and fifty-two blows, or a final blow of 152,000 centimetre-grammes; the total energy expended was 11,628,000 centimetre-grammes.

Test No. 21. This cube was also of a very dark-gray color, and striation was distinct. The striation had a decided curve, to which the load was applied at an angle. Its height was 0.517 of an inch. It stood one hundred and eighteen blows, or a final blow of 118,000 centimetre-grammes; the total energy expended was 6,786,000 centimetre-grammes.

Test No. 22. Of a very dark-gray color. The striation was distinct, to which the load was applied parallel. Height of cube, 0.513 of an inch. It stood one hundred and two blows, or a final blow of 102,000 centimetre-grammes; the total energy expended was 5,253,000 centimetre-grammes.

TABLE OF RESULTS

Locality	Test No.	Direction of blow	Number of blows to produce fracture	Energy of final blow in centimetre-grammes	Total energy expended in producing fracture, in centimetre-grammes
Burma (No. 7)	1	Right angles to cleavage	100	100,000	5,050,000
Burma (No. 7)	2	Parallel to cleavage	103	103,000	5,356,000
Burma (No. 7)	3	Parallel to cleavage	112	112,000	6,328,000
Burma (No. 7)	4	Right angles to cleavage	131	131,000	8,646,000
China (No. 96)	5	Right angles to cleavage	81	81,000	3,321,000
China (No. 96)	6	Parallel to cleavage	39	39,000	780,000
New Zealand (No. 162)	7	Right angles to cleavage	85	85,000	3,655,000
Jordansmühl (No. 134*a*)	8	Parallel to cleavage	32	32,000	528,000
Jordansmühl (No. 134*a*)	9	Angle of 45° to striation	39	39,000	780,000
Jordansmühl (No. 134*a*)	10	Right angles to striation	37	37,000	703,000
Siberia (No. 130)	11	Parallel to cleavage	32	32,000	528,000
Siberia (No. 130)	12	Angle of 40° to cleavage	48	48,000	1,176,000
Siberia (No. 130)	13	Angle of 45° to cleavage	48	48,000	1,176,000
Turkistan (No. 78)	14	No cleavage or striation	68	68,000	2,346,000
Turkistan (No. 78)	15	Parallel to striation	76	76,000	2,926,000
Turkistan (No. 78)	16	Right angles to striation	82	82,000	3,403,000
Turkistan (No. 67)	17	No cleavage or striation	41	41,000	861,000
Turkistan (No. 67)	18	No cleavage or striation	32	32,000	528,000
Turkistan (No. 67)	19	No cleavage or striation	38	38,000	741,000
Turkistan (No. 79)	20	Right angles to striation	152	152,000	11,628,000
Turkistan (No. 79)	21	Angle to striation	118	118,000	6,786,000
Turkistan (No. 79)	22	Parallel to striation	102	102,000	5,253,000

TABLE OF AVERAGE RESULTS

Locality	Direction of blow to cleavage or striation	Number of cubes used	Number of blows to produce fracture	Energy of final blow in centimetre-grammes	Total energy expended in producing fracture, in centimetre-grammes
Burma	Parallel	2	107.5	107,500	5,842,000
	Right angles	2	115.5	115,500	6,848,000
China	Parallel	1	39	39,000	780,000
	Right angles	1	81	81,000	3,321,000
New Zealand	Right angles	1	85	85,000	3,655,000
Jordansmühl	Parallel	1	32	32,000	528,000
	Right angles	1	37	37,000	703,000
	Angle of 45°	1	39	39,000	780,000
Siberia	Parallel	1	32	32,000	528,000
	Angle of 40°	1	48	48,000	1,176,000
	Angle of 45°	1	48	48,000	1,176,000
Turkistan (Green)	No cleavage or striation	1	68	68,000	2,346,000
	Parallel	1	76	76,000	2,926,000
	Right angles	1	82	82,000	3,403,000
Turkistan (White)	No cleavage or striation	3	37	37,000	710,000
Turkistan (Gray)	Right angles	1	152	152,000	11,628,000
	Angle	1	118	118,000	6,786,000
	Parallel	1	102	102,000	5,253,000

The table of average results shows, as was anticipated, that the cubes broke under a smaller load when the blow was applied parallel to the cleavage or striation than when at right angles or at an angle to it. This conclusion, however, is not completely borne out by the Burma samples, one of which (No. 4) showed greater strength and another (No. 1) less strength when the blow was applied at right angles than either of the two other samples tested parallel to their cleavage planes. The number of samples tested of any one variety was, however, insufficient to demonstrate this point with certainty, and the great difference in the strength of the two China samples (Nos. 5 and 6) may be due to some cause other than the difference in the direction of the blows.

The most important point brought out by the tests is the very high resistance offered by jade to impact, the average for all the tests being nearly seventy-two blows, whereas from the four cubes of slate tested the average was sixteen blows, and from three cubes of granite twenty-three blows. The highest resisting power which has previously been obtained with this method of testing was with two centimetre cubes of diabase, one of which sustained sixty-eight blows before fracture; but as this test was made on a much larger cube than those used for the jade, the results are not directly comparable.

A comparison of the results of the different tests shows a decided superiority for cube No. 20 of the gray Turkistan nephrite, with cube No. 4 of the Burmese jadeite next, these two varieties standing higher than the others. The average results of the eight varieties of jade tested are given below in the order of their resistance to impact.

Turkistan (No. 79), 124 blows; Burma, 112 blows; New Zealand, 85 blows;
Turkistan (No. 78), 75 blows; China, 60 blows; Siberia, 43 blows;
Turkistan (No. 67), 37 blows; and Jordansmühl, 36 blows.

The compression tests were made by Professor Ira Harvey Woolson, E.M., of the Department of Mechanical Engineering at Columbia University, New York.

In addition to the inch-cubes of the material already described as having been used in the impact tests (Nos. 7, 67, 78, 79, 96, 130, 134*a*, 162), Professor Woolson tested cubes of three other specimens, one of which was of nephrite from China (but, like the others so labelled, probably of Turkistan origin), and two were of Burmese jadeite, viz.:

Number 4. Jadeite boulder from Burma; specific gravity, 3.2176; hardness, 7; color, dead-white with bluish-green markings; homogeneous and compact, showing the included crystals very clearly.

Number 15. Crude jadeite from Burma; specific gravity, 3.2466; hardness, 7; color, dark brownish-green on four sides of the cube, and yellowish-green on the other two sides.

Number 97. Fragment of a nephrite boulder from China (probably Turkistan); specific gravity, 2.9825; hardness, 6.5; color, light sage-green; very compact and homogeneous, showing scarcely any stratification. A number of black metallic spots—probably chromic iron—present.

His report is as follows:

COMPRESSION TESTS ON JADE

With the exception of the two preliminary tests made by Professor Jaczewsky on Siberian jade (already referred to), no attempts to determine scientifically the compressive strength of jade have ever been made. The results now given may therefore be styled unique and of unusual interest.

The tests were made on an Emery hydraulic testing-machine, the most accurate testing-machine known, and, in view of the interest attaching to the material, were executed with the utmost care.

The specimens were all inch-cubes, sawn to shape and rubbed to a smooth, dull finish. So far as possible, they were all tested on bed—that is, the load was applied at right angles to the bedding planes; but in two specimens, Nos. 4 and 7, the stratification was not sufficiently distinct to make a positive determination. The compression faces were finished with much care, and their contact with the steel compression plates of

the testing-machine made as perfect as possible. To insure still more perfect support and uniform distribution of load, a sheet of stiff blotting-paper was inserted between each face and the steel plate; experience having shown that this material has no effect except to improve the support. In the case of Nos. 67, 78, and 130, the cubes were bedded in plaster of Paris. The lower plate of the machine was fitted with a spherical adjustment which made it possible to apply the load squarely to the two compression faces of the specimens, even though they might be slightly out of parallel.

With the exception of No. 7 *bis*, a compressometer was attached to each specimen on a gauged length of three quarters of an inch, and the amount of compression measured in hundred thousandths of an inch for each 1000 pounds per square inch increment of load, in the case of the first six specimens. In all other cases the compression measurements were made at, each, 10,000 pounds of increment. On one specimen 80 readings were taken, on three others 75 readings each, while on one 54 and on another only 40 readings were obtained because the specimens failed at loads only slightly above these points.

Seventeen cubes in all were tested, viz.: two of each of the following: Nos. 7, 67, 78, 79, 130, and 134; and only one each of Nos. 4, 15, 96, 97, and 162. A brief description of each test follows:

Number 7. The cube measured 1.001″ × 1.013″ × 1.009″; area, 1.022 square inches; a flaw in one corner. The load was applied to the apparent bed of the material. When the load had reached 75,000 pounds per square inch, the compressometer was removed, and the width was found to have increased from 1.013″ to 1.014″, and the thickness from 1.009″ to 1.011″. The total compression in $\frac{3}{4}$″ at a pressure of 75,000 pounds per square inch was 0.0027 inch = $\frac{36}{100}$ of one per cent. At 94,000 pounds pressure a slight crack appeared on one corner, and the specimen failed suddenly with a sharp report at 94,450 pounds, breaking into numerous small fragments. Ultimate strength per square inch, 92,416 pounds. Time required, two hours.

Number 7 *bis*. The cube measured 1.004″ × 1.021″ × 1.018″; area, 1.039 square inches; two flaws in one corner. As in the previous specimen, the load was applied at right angles to the apparent bed. The specimen began to show white mottled spots on the exposed faces at 65,000 pounds. These gradually increased until crushing began. The first crack was observed when the applied load had reached 76,400 pounds, and at 79,180 pounds the specimen failed suddenly with a sharp report, breaking into fine pieces, somewhat prismatic. The ultimate strength proved to be 76,208 pounds per square inch. Time, one and a half hours. The compressometer was not used on this specimen.

Number 96. A cube apparently of very compact material, with a few spots of what seemed to be manganous oxide. It measured 0.998″ × 1.016″ × 1.013″; area in square inches, 1.029. Measured at a load of 75,000 pounds per square inch, and just after removing the compressometer, the width had increased from 1.016″ to 1.018″, and the thickness from 1.013″ to 1.015″. The total compression in $\frac{3}{4}$″ at a load of 75,000 pounds per square inch was 0.0036″ = $\frac{48}{100}$ of one per cent. At 80,100 pounds of applied load one corner flaked slightly, and at 94,500 pounds the specimen failed suddenly with a sharp report, being completely pulverized. The ultimate strength per square inch was 91,836 pounds. Time of test, two hours and twenty-five minutes.

Number 162. A cube cut almost horizontally across the schistose structure of the material; color, rich dark green; dimensions, 0.955″ × 0.980″ × 0.972″; area in square inches, 0.952. When a load of 65,000 pounds per square inch was reached, cleavage planes which showed in the original cube became whitish, and were decidedly white on one side at 75,000 pounds per square inch. A few white cracks also were visible at this load, but no spalling or breaking occurred until failure. Measured at a load of 75,000 pounds per square inch, just after the removal of the compressometer, the width was found to have increased from 0.980″ to 0.987″, and the thickness from 0.972″ to 0.975″. The total compression in $\frac{3}{4}$″ at 75,000 pounds load per square inch = 0.0037 inch, or $\frac{49}{100}$ of one per cent. The ultimate strength was 92,332 pounds per square inch, at which the specimen failed suddenly with a sharp report, the cube being reduced to sand and fine fragments. Time occupied in the experiment, two and a half hours.

Number 15. A cube of crude jadeite, in parts coarsely granular; dimensions, 0.945″ × 0.968″ × 0.981″; area, 0.949 square inch. The specimen, which was not very perfect, and seemed to be filled with cleavage planes or seams in various directions, failed suddenly with only a slight report, while the compressometer was still attached, at the maximum load of 38,934 pounds. The total compression in $\frac{3}{4}$″ at 40,000 pounds load

104

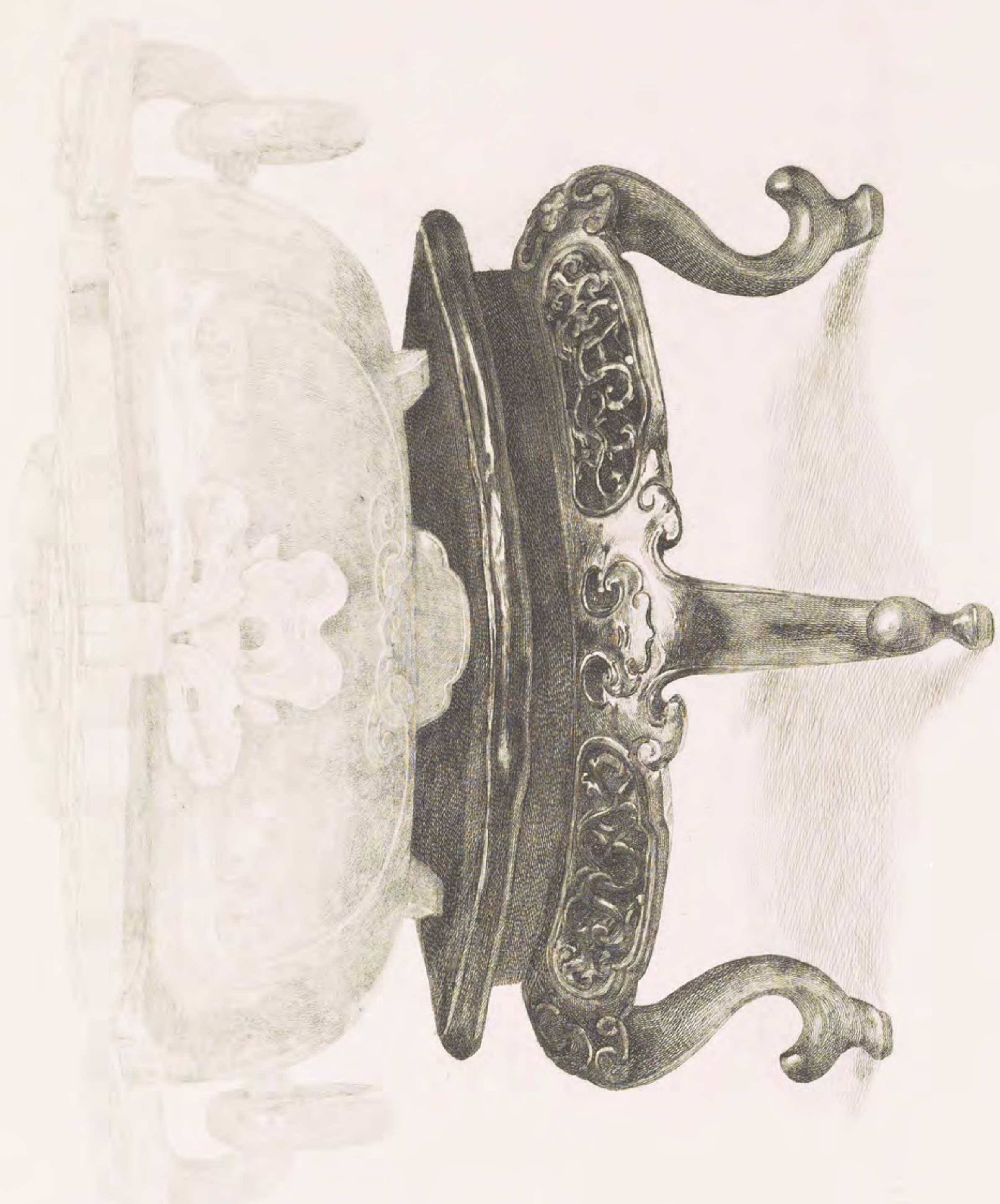
No. 600

MARRIAGE WINE-CUP

(*Ho-huan Pei*)

Ch'ien-lung (1736–95)

Nephrite



per square inch was 0.00075″ = $\frac{1}{10}$ of one per cent. (No. 4, Burmese jadeite, when measured at the same load, gave the same compression.) Ultimate strength of specimen, 41,000 pounds per square inch. Time, one hour.

Number 4. Cube of homogeneous and compact jadeite, clearly showing included crystals; size, 0.930″ × 0.946″ × 0.807″; area in square inches, 0.763. The specimen failed suddenly, without report, at a maximum applied load of 41,987 pounds, while the compressometer was still attached to it, so that no lateral deformations were measured. Compressometer readings were made on gauged length of $\frac{3}{4}$″ for each 1000 pounds up to 55,000 pounds per square inch. At 54,000 pounds per square inch the total compression was 0.0012″ = $\frac{16}{100}$ of one per cent.; at 40,000 pounds it equalled 0.00074″, or $\frac{1}{10}$ of one per cent. No. 15, measured at the same load, gave the same compression. At the crushing-point the specimen broke into small fragments, somewhat prismatic. The ultimate strength was 55,000 pounds per square inch. Time, one hour and ten minutes.

Number 97. Cube of compact and homogeneous material showing scarcely any stratification. A number of black metallic spots, probably chromic iron, present; dimensions, 0.956″ × 0.957″ × 1.006″; area in square inches, 0.962. At 87,300 pounds per square inch white spots began to appear beneath the surface of the specimen; while at 89,500 pounds per square inch it had as a whole a mottled or cloudy appearance. With a maximum load of 91,600 pounds it was suddenly shattered to fine bits, with a sharp report. Much sand produced. Ultimate strength, 95,150 pounds per square inch. Time, two hours. The compressometer was used and measurements taken on a gauged length of $\frac{3}{4}$″ for each 1000 pounds of load up to 80,000 pounds per square inch. At 75,000 pounds the total compression per square inch = 0.00206″ = $\frac{27}{100}$ of one per cent. At 80,000 pounds it was 0.00228″, or $\frac{3}{10}$ of one per cent.

Number 134*a*. Cube measured 1.005″ × 0.995″ × 0.997″; area in square inches, 0.992. Tested on bed, and bedded with blotting-paper; failed without warning, but with a dull crushing sound, the compressometer still attached, at a maximum load of 23,800 pounds, splitting more or less into parallel plates, which did not fly apart and were nearly at right angles to the compression faces. Ultimate strength per square inch, 23,992 pounds. Actual time of test, twenty minutes.

Number 134*a bis*. Dimensions of cube, 1.030″ × 1.007″ × 1.011″; area in square inches, 1.018. Tested on bed, and bedded with blotting-paper; failed without warning at 26,000 pounds, breaking with wedge-shaped fracture and while the compressometer was still attached. The pieces did not fly apart, but held together in cube shape after fracture. Ultimate strength per square inch, 25,540 pounds. Time occupied in the test, twenty-five minutes.

Number 130. Cube measured 0.999″ × 0.995″ × 0.993″; area in square inches, 0.998. Tested on bed, and bedded with plaster of Paris. Measured at a load of 50,000 pounds, the compression in $\frac{3}{4}$ of an inch was 0.0027″ = $\frac{36}{100}$ of one per cent. Maximum load, 52,600 pounds; ultimate strength per square inch, 53,238 pounds. The specimen failed with a dull report; fracture wedge-shaped; white and powdery on fractured surface. Actual time occupied in the test, forty minutes.

Number 130 *bis*. Cube measured 1.003″ × 1.004″ × 1.005″; area in square inches, 1.009. Tested on bed, and bedded in the same manner as the preceding; maximum load, 36,200 pounds; ultimate strength per square inch, 35,877 pounds. Dull report and character of fracture same as the preceding.

Number 78. Cube measured 1.005″ × 1.012″ × 1.010″; area in square inches, 1.022. Tested on bed, and bedded in plaster of Paris. There were indications of a cleavage plane running diagonally through the cube. When the specimen was crushed this plane opened and showed a dark stain indicating that there was an actual crack along this plane. Maximum load, 20,000 pounds; ultimate strength per square inch, 19,269 pounds; fracturing, with dull sound, into coarse angular fragments. Slight cracking sound heard when the load reached 10,000 pounds. Specimen failed with the compressometer still attached. Actual time of test, twenty minutes.

Number 78 *bis*. Cube measured 1.019″ × 1.016″ × 1.009″; area in square inches, 1.025. Tested on bed, and bedded in plaster of Paris. This also showed a diagonal cleavage plane, but after crushing there was no indication that an actual crack had existed. Maximum load, 28,100 pounds; ultimate strength per square inch, 27,414 pounds. A small corner flaked off at 12,200 pounds. The specimen failed, with a dull sound,

while the compressometer was still attached, breaking into coarse angular fragments. Time consumed in the test, twenty-five minutes.

Number 67. Dimensions of cube, 1.005″ × 0.995″ × 0.993″; area in square inches, 0.998. Tested on bed, and bedded with plaster of Paris. Failed without warning, but with a sharp report, at a maximum load of 52,100 pounds, breaking into small fragments; ultimate strength per square inch, 52,732 pounds. The specimen showed small cleavage cracks, more or less, throughout the cube, but these did not appear to affect the strength of the specimen. No compression measurements obtained. Time, forty minutes.

Number 67 *bis*. Dimensions of cube, 1.003″ × 0.994″ × 0.990″; area in square inches, 0.984. Tested on bed, and bedded with blotting-paper. The specimen failed suddenly, with a sharp report, at a maximum load of 65,400 pounds, breaking into small fragments. The cube showed cleavage planes or cracks, one of which ran diagonally nearly across it; but these cracks apparently did not cause fracture or chipping, and there was no evidence that failure occurred first on these lines. Ultimate strength per square inch, 66,463 pounds. The compressometer was removed at 50,000 pounds. Total compression in $\frac{3}{4}''$ at that load was $0.0024'' = \frac{33}{100}$ of one per cent. Actual time occupied in the test, thirty minutes.

Number 79. Cube measured 1.015″ × 1.019″ × 1.020″; area in square inches, 1.039. Tested on bed, and bedded with blotting-paper. At a load of 75,000 pounds, when slight indications of a crack appeared, the compressometer was removed; the total compression in $\frac{3}{4}''$ at this load being $0.0024'' = \frac{33}{100}$ of one per cent. Maximum load, 85,600 pounds; ultimate strength per square inch, 82,387 pounds. The specimen failed with a sharp report, being crushed to small fragments. Time occupied in the test, forty minutes.

Number 79 *bis*. Cube measured 1.032″ × 1.026″ × 1.030″; area in square inches, 1.057. Tested on bed, and bedded on blotting-paper; slight crack occurred at 69,100 pounds; at a load of 70,000 pounds the specimen was crushed to small fragments, with a sharp report, and with the compressometer still attached; ultimate strength per square inch, 66,225 pounds. Total compression in $\frac{3}{4}''$ at a load of 66,000 pounds was $0.0034'' = \frac{45}{100}$ of one per cent. Time, forty minutes.

SUMMARY OF COMPRESSION TESTS

Number of specimen	Material	Maximum load in lbs.	Ultimate strength per square inch in lbs.	Total compression in inches	Measured at load of	Percentage of compression
7	Jadeite	94,450	92,416	.0027	75,000 lbs.	36/100 of 1%
7 *bis*	Jadeite	79,180	76,208		Not measured	
96	Nephrite	94,500	91,836	.0036	75,000 lbs.	48/100 of 1%
162	Nephrite	87,800	92,332	.0037	75,000 lbs.	49/100 of 1%
15	Jadeite	38,934	41,000	.00075	40,000 lbs.	1/10 of 1%
4	Jadeite	41,987	55,000	.0012	54,000 lbs.	16/100 of 1%
97	Nephrite	91,600	95,150	.00206	75,000 lbs.	27/100 of 1%
				.00228	80,000 lbs.	3/10 of 1%
134*a*	Nephrite	23,800	23,992		Not measured	
134*a bis*	Nephrite	26,000	25,540		" "	
130	Nephrite	52,600	53,238	.0027	50,000 lbs.	36/100 of 1%
130 *bis*	Nephrite	36,200	35,877		Not measured	
78	Nephrite	20,000	19,569		" "	
78 *bis*	Nephrite	28,100	27,414		" "	
67	Nephrite	52,100	52,732		" "	
67 *bis*	Nephrite	65,400	66,463	.0024	50,000 lbs.	33/100 of 1%
79	Nephrite	85,600	82,387	.0024	75,000 lbs.	38/100 of 1%
79 *bis*	Nephrite	70,000	66,225	.0034	66,000 lbs.	45/100 of 1%

These tests show a very wide range of variation in resistance to compression in the different specimens. Nos. 78 and 134*a* are exceptionally low, explainable, no doubt, in the case of No. 78, by the diagonal crack found in the cubes, and in No. 134*a* by the fact that a chemical analysis showed the possible existence of some decomposition products like talc or serpentine. Neglecting these two specimens and taking the average of those specimens that were tested in duplicate, we have a very remarkable showing; the crushing-

point ranging in the jadeites from 41,000 pounds per square inch to 84,317 pounds per square inch, and in the nephrites from 44,577 pounds to 95,000 pounds per square inch, and it is probable that these figures are fairly typical of the mineral.

When compared with the values given in the accompanying table for building-stone, steel, and cast iron, the average of many tests in all parts of the world, the greater tenacity of jade becomes very apparent.

Sandstone,	per square inch,			5,000 to 15,000 lbs.
Limestone,	"	"	"	7,000 " 20,000 "
Granite,	"	"	"	15,000 " 35,000 "
Mild Steel,	"	"	"	40,000 " 60,000 "
Medium Steel,	"	"	"	60,000 " 80,000 "
Cast Iron,	"	"	"	60,000 " 80,000 "
JADE,	"	"	"	41,000 " 95,000 "

It is true that special hard grades of steel and cast iron will stand much more than is indicated here, but it is scarcely fair to compare the strength of a mineral with that of such metals.

A few isolated cases are on record where samples of very fine-grained granite, bluestone, or vitrified sandstone have withstood 40,000 to 45,000 pounds per square inch, but these are rare exceptions. So far as known, these tests prove this material to be one of the strongest of all the mineral kingdom, and that it possesses rare physical characteristics independent of its beauty and ornamental features.

The following tables, and the remarks which follow them, show the physical properties determined by measurements of the deformations produced by successive loads of 1000 pounds per square inch in six of the specimens, viz.: Nos. 7, 96, 162, 15, 97, and 4. As the principal object of the tests was to determine the strength of the material, it was deemed unnecessary to make more numerous measurements of the total compression; and, therefore, in the remaining specimens these measurements were taken only at every increment of load of 10,000 pounds, and the results show a close agreement in all cases where the specimens tested sustained a sufficient load to be compared with those in which compression was measured at 1000 pounds increment. Nor was it deemed necessary to calculate the modulus of elasticity of the specimens numbered 67, 78, 79, 130, and 134*a*, as that had been sufficiently established in connection with the compressometer measurements of the first six specimens tested.

No. 7

Burmese Jadeite — LOADS AND CORRESPONDING DEFORMATIONS — Area, 1.1042 Sq. In.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
500	.01840				24,000	.01910	.00070		25,700,000
700	.01844	.00004			25,000	.01915	.00075	.00005	25,000,000
1,000	.01850	.00010	.00006		26,000	.01920	.00080	.00005	24,400,000
2,000	.01850	.00010		14,900,000?	27,000	.01920	.00080		25,300,000
3,000	.01860	.00020	.00010	11,200,000	28,000	.01925	.00085	.00005	24,700,000
4,000	.01866	.00026	.00004	11,500,000	29,000	.01925	.00085		25,600,000
5,000	.01866	.00026		14,400,000	30,000	.01925	.00085		26,500,000
6,000	.01871	.00031	.00005	14,500,000	31,000	.01930	.00090	.00005	25,800,000
7,000	.01871	.00031		16,900,000	32,000	.01930	.00090		26,600,000
8,000	.01871	.00031		19,300,000	33,000	.01930	.00090		27,500,000
9,000	.01877	.00037	.00006	18,200,000	34,000	.01930	.00090		28,400,000
10,000	.01877	.00037		20,200,000	35,000	.01930	.00090		29,200,000
11,000	.01877	.00037		22,200,000	36,000	.01935	.00095	.00005	28,400,000
12,000	.01877	.00037		24,300,000	37,000	.01935	.00095		29,200,000
13,000	.01877	.00037		26,400,000	38,000	.01935	.00095		30,000,000
14,000	.01883	.00043	.00006	24,400,000	39,000	.01940	.00100	.00005	29,200,000
15,000	.01888	.00048	.00005	23,400,000	40,000	.01940	.00100		30,000,000
16,000	.01888	.00048		25,000,000	41,000	.01940	.00100		30,700,000
17,000	.01894	.00054	.00006	23,600,000	42,000	.01945	.00105	.00005	30,000,000
18,000	.01894	.00054		25,000,000	43,000	.01945	.00105		30,700,000
19,000	.01899	.00059	.00005	24,100,000	44,000	.01950	.00110	.00005	30,000,000
20,000	.01899	.00059		25,400,000	45,000	.01956	.00116	.00006	29,100,000
21,000	.01906	.00066	.00007	23,900,000	46,000	.01961	.00121	.00005	28,500,000
22,000	.01906	.00066		25,000,000	47,000	.01967	.00127	.00006	27,800,000
23,000	.01910	.00070	.00004	24,600,000	48,000	.01972	.00132	.00005	28,000,000

No. 7. LOADS AND CORRESPONDING DEFORMATIONS (*Continued*)

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
49,000	.01972	.00132		28,600,000	63,000	.02016	.00176		26,800,000
50,000	.01978	.00138	.00006	27,200,000	64,000	.02022	.00182	.00006	26,300,000
51,000	.01978	.00138		27,700,000	65,000	.02027	.00187	.00005	26,100,000
52,000	.01978	.00138		28,200,000	66,000	.02033	.00193	.00006	25,600,000
53,000	.01983	.00143	.00005	27,800,000	67,000	.02038	.00198	.00005	25,400,000
54,000	.01989	.00149	.00006	27,200,000	68,000	.02049	.00209	.00011	24,400,000
55,000	.01989	.00149		27,700,000	69,000	.02060	.00220	.00011	23,500,000
56,000	.01994	.00154	.00005	27,300,000	70,000	.02072	.00232	.00012	22,700,000
57,000	.01994	.00154		27,700,000	71,000	.02090	.00250	.00018	21,300,000
58,000	.02000	.00160	.00006	27,200,000	72,000	.02096	.00256	.00006	21,000,000
59,000	.02005	.00165	.00005	26,800,000	73,000	.02102	.00262	.00006	20,900,000
60,000	.02010	.00170	.00005	26,400,000	74,000	.02108	.00268	.00006	20,700,000
61,000	.02010	.00170		26,900,000	75,000	.02114	.00274	.00006	20,500,000
62,000	.02016	.00176	.00006	26,400,000	*92,416				
					* Breaking Load				

No. 96

Chinese Nephrite — LOADS AND CORRESPONDING DEFORMATIONS — Area, 1.029 Sq. In.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
700	.02220				39,000	.02463	.00243	.00006	12,000,000
1,000	.02230	.00010		7,500,000?	40,000	.02468	.00248	.00005	12,100,000
2,000	.02270	.00050		3,000,000	41,000	.02468	.00248		12,300,000
3,000	.02287	.00067	.00017	3,300,000	42,000	.02477	.00257	.00009	12,300,000
4,000	.02294	.00074	.00004	4,050,000	43,000	.02479	.00259	.00002	12,400,000
5,000	.02300	.00080	.00006	4,700,000	44,000	.02479	.00259		12,700,000
6,000	.02307	.00087	.00007	5,200,000	45,000	.02479	.00259		13,000,000
7,000	.02314	.00094	.00007	5,600,000	46,000	.02485	.00265	.00006	13,000,000
8,000	.02320	.00100	.00006	6,000,000	47,000	.02490	.00270	.00005	13,000,000
9,000	.02320	.00100		6,700,000	48,000	.02495	.00275	.00005	13,100,000
10,000	.02326	.00106	.00006	7,000,000	49,000	.02500	.00280	.00005	13,200,000
11,000	.02339	.00119	.00013	6,300,000?	50,000	.02500	.00280		13,400,000
12,000	.02346	.00126	.00007	7,200,000	51,000	.02500	.00280		13,600,000
13,000	.02353	.00133	.00007	7,300,000	52,000	.02500	.00280		13,900,000
14,000	.02360	.00140	.00007	7,500,000	53,000	.02505	.00285	.00005	13,900,000
15,000	.02360	.00140		8,000,000	54,000	.02511	.00291	.00006	13,900,000
16,000	.02366	.00146	.00006	8,200,000	55,000	.02516	.00296	.00005	13,900,000
17,000	.02372	.00152	.00006	8,400,000	56,000	.02522	.00302	.00006	14,000,000
18,000	.02372	.00152		8,900,000	57,000	.02522	.00302		14,100,000
19,000	.02378	.00158	.00006	9,000,000	58,000	.02528	.00308	.00006	14,100,000
20,000	.02384	.00164	.00006	9,100,000	59,000	.02533	.00313	.00005	14,200,000
21,000	.02384	.00164		9,600,000	60,000	.02533	.00313		14,300,000
22,000	.02390	.00170	.00006	9,700,000	61,000	.02533	.00313		14,600,000
23,000	.02397	.00177	.00007	9,700,000	62,000	.02539	.00319	.00006	14,600,000
24,000	.02403	.00183	.00006	9,900,000	63,000	.02544	.00324	.00005	14,600,000
25,000	.02403	.00183		10,200,000	64,000	.02550	.00330	.00006	14,600,000
26,000	.02410	.00190	.00007	10,300,000	65,000	.02555	.00335	.00005	14,600,000
27,000	.02420	.00190			66,000	.02555	.00335		14,700,000
28,000	.02416	.00196	.00006	10,700,000	67,000	.02555	.00335		14,900,000
29,000	.02423	.00203	.00007	10,700,000	68,000	.02560	.00340	.00005	15,000,000
30,000	.02423	.00203		11,100,000	69,000	.02560	.00340		15,200,000
31,000	.02429	.00209	.00006	11,100,000	70,000	.02566	.00346	.00006	15,200,000
32,000	.02435	.00215	.00006	11,200,000	71,000	.02572	.00352	.00006	15,200,000
33,000	.02435	.00215		11,500,000	72,000	.02577	.00357	.00005	15,200,000
34,000	.02440	.00220	.00005	11,600,000	73,000	.02577	.00357		15,300,000
35,000	.02446	.00226	.00006	11,600,000	74,000	.02583	.00363	.00006	15,300,000
36,000	.02446	.00226		11,900,000	75,000	.02588	.00368	.00005	15,300,000
37,000	.02451	.00231	.00005	12,000,000	*91,836				
38,000	.02457	.00237	.00006	12,000,000	* Breaking Load				

No. 162

New Zealand Nephrite — LOADS AND CORRESPONDING DEFORMATIONS — Area, .952 Sq. In.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
500	.00630				38,000	.00790	.00160		17,800,000
800	.00650	.00020		3,000,000	39,000	.00795	.00165	.00005	17,700,000
1,000	.00650	.00020		3,800,000	40,000	.00799	.00169	.00004	17,700,000
2,000	.00665	.00035	.00015	4,300,000	41,000	.00799	.00169		18,100,000
3,000	.00673	.00043	.00008	5,200,000	42,000	.00803	.00173	.00004	18,200,000
4,000	.00677	.00047	.00004	6,400,000	43,000	.00807	.00177	.00004	18,200,000
5,000	.00681	.00051	.00004	7,400,000	44,000	.00816	.00186	.00009	17,700,000
6,000	.00683	.00053	.00002	8,500,000	45,000	.00825	.00195	.00009	17,300,000
7,000	.00685	.00055	.00002	9,500,000	46,000	.00830	.00200	.00005	17,200,000
8,000	.00689	.00059	.00004	10,200,000	47,000	.00834	.00204	.00004	17,200,000
9,000	.00697	.00067	.00008	10,100,000	48,000	.00839	.00209	.00005	17,200,000
10,000	.00698	.00068	.00001	11,000,000	49,000	.00843	.00213	.00004	17,200,000
11,000	.00699	.00069	.00001	12,000,000	50,000	.00847	.00217	.00004	17,200,000
12,000	.00700	.00070	.00001	12,800,000	51,000	.00857	.00227	.00010	16,800,000
13,000	.00703	.00073	.00003	13,400,000	52,000	.00861	.00231	.00004	16,800,000
14,000	.00704	.00074	.00001	14,200,000	53,000	.00866	.00236	.00005	16,800,000
15,000	.00705	.00075	.00001	15,000,000	54,000	.00871	.00241	.00005	16,800,000
16,000	.00706	.00076	.00001	15,800,000	55,000	.00876	.00246	.00005	16,700,000
17,000	.00706	.00076		16,800,000	56,000	.00881	.00251	.00005	16,700,000
18,000	.00707	.00077	.00001	17,500,000	57,000	.00886	.00256	.00005	16,700,000
19,000	.00709	.00079	.00002	18,000,000	58,000	.00891	.00261	.00005	16,800,000
20,000	.00710	.00080	.00001	18,700,000	59,000	.00891	.00261		16,900,000
21,000	.00717	.00087	.00007	18,100,000	60,000	.00896	.00266	.00005	16,900,000
22,000	.00720	.00090	.00003	18,300,000	61,000	.00902	.00272	.00006	16,800,000
23,000	.00723	.00093	.00003	18,500,000	62,000	.00902	.00272		17,100,000
24,000	.00730	.00100	.00007	18,000,000	63,000	.00907	.00277	.00005	17,000,000
25,000	.00734	.00104	.00004	18,000,000	64,000	.00913	.00283	.00006	16,900,000
26,000	.00737	.00107	.00003	18,200,000	65,000	.00919	.00289	.00006	16,800,000
27,000	.00744	.00114	.00007	17,700,000	66,000	.00924	.00294	.00005	16,800,000
28,000	.00747	.00117	.00003	17,900,000	67,000	.00930	.00300	.00006	16,700,000
29,000	.00750	.00120	.00003	18,100,000	68,000	.00935	.00305	.00005	16,700,000
30,000	.00755	.00125	.00005	18,500,000	69,000	.00946	.00316	.00011	16,400,000
31,000	.00759	.00129	.00004	18,000,000	70,000	.00952	.00322	.00006	16,300,000
32,000	.00763	.00133	.00004	18,000,000	71,000	.00957	.00327	.00005	16,200,000
33,000	.00767	.00137	.00004	18,000,000	72,000	.00976	.00346	.00019	15,600,000
34,000	.00770	.00140	.00003	18,200,000	73,000	.00982	.00352	.00006	15,500,000
35,000	.00774	.00144	.00004	18,200,000	74,000	.00994	.00364	.00012	15,300,000
36,000	.00786	.00156	.00012	17,300,000	75,000	.01000	.00370	.00006	15,700,000
37,000	.00790	.00160	.00004	17,300,000	*92,332				

*Breaking Load

No. 15

Burmese Jadeite — LOADS AND CORRESPONDING DEFORMATIONS — Area, .9496 Sq. In.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
500					11,000	.00250	.00022		37,500,000
1,000	.00228				12,000	.00250	.00022		41,000,000
2,000	.00232	.00004		37,500,000	13,000	.00255	.00027	.00005	36,200,000
3,000	.00238	.00010	.00006	22,500,000	14,000	.00255	.00027		39,000,000
4,000	.00241	.00013	.00003	23,000,000	15,000	.00255	.00027		41,700,000
5,000	.00241	.00013		28,800,000	16,000	.00260	.00032	.00005	37,500,000
6,000	.00246	.00018	.00005	25,000,000	17,000	.00260	.00032		39,800,000
7,000	.00250	.00022	.00004	23,900,000	18,000	.00265	.00037	.00005	36,500,000
8,000	.00250	.00022		27,300,000	19,000	.00270	.00042	.00005	34,000,000
9,000	.00250	.00022		30,700,000	20,000	.00270	.00042		35,700,000
10,000	.00250	.00022		34,100,000	21,000	.00275	.00047	.00005	33,500,000

No. 15. LOADS AND CORRESPONDING DEFORMATIONS (*Continued*)

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
22,000	.00275	.00047		35,100,000	33,000	.00284	.00056		44,200,000
23,000	.00275	.00047		36,700,000	34,000	.00284	.00056		45,500,000
24,000	.00279	.00051	.00004	35,300,000	35,000	.00284	.00056		47,000,000
25,000	.00279	.00051		36,800,000	36,000	.00289	.00061	.00005	44,200,000
26,000	.00279	.00051		38,300,000	37,000	.00294	.00066	.00005	42,100,000
27,000	.00279	.00051		39,700,000	38,000	.00294	.00066		43,200,000
28,000	.00284	.00056	.00005	37,500,000	39,000	.00298	.00070	.00004	41,800,000
29,000	.00284	.00056		38,800,000	40,000	.00303	.00075	.00005	40,000,000
30,000	.00284	.00056		40,100,000		.00324	.00096	.00021	32,000,000
31,000	.00284	.00056		41,500,000	*41,000				
32,000	.00284	.00056		42,800,000	* Breaking Load				

No. 97

Chinese Nephrite — LOADS AND CORRESPONDING DEFORMATIONS — Area, .9627 Sq. In.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
500	.02490				39,000	.02599	.00109	.00005	26,800,000
600	.02495	.00005		9,000,000	40,000	.02599	.00109		27,500,000
700	.02500	.00010	.00005	5,200,000	41,000	.02599	.00109		28,200,000
800	.02500	.00010		6,000,000	42,000	.02605	.00115	.00006	27,400,000
900	.02505	.00015	.00005	4,500,000	43,000	.02605	.00115		28,000,000
1,000	.02505	.00015		5,000,000	44,000	.02605	.00115		28,600,000
2,000	.02511	.00021	.00006	7,100,000	45,000	.02605	.00115		29,300,000
3,000	.02517	.00027	.00006	8,300,000	46,000	.02605	.00115		29,900,000
4,000	.02522	.00032	.00005	9,400,000	47,000	.02610	.00120	.00005	29,400,000
5,000	.02522	.00032		11,700,000	48,000	.02615	.00125	.00005	29,600,000
6,000	.02528	.00038	.00006	11,800,000	49,000	.02620	.00130	.00005	28,200,000
7,000	.02528	.00038		13,800,000	50,000	.02620	.00130		28,800,000
8,000	.02528	.00038		15,700,000	51,000	.02620	.00130		29,400,000
9,000	.02528	.00038		17,800,000	52,000	.02620	.00130		29,900,000
10,000	.02528	.00038		19,700,000	53,000	.02625	.00135	.00005	29,400,000
11,000	.02533	.00043	.00005	19,400,000	54,000	.02630	.00140	.00005	28,900,000
12,000	.02533	.00043		20,900,000	55,000	.02630	.00140		29,400,000
13,000	.02533	.00043		22,600,000	56,000	.02635	.00145	.00005	29,000,000
14,000	.02533	.00043		24,400,000	57,000	.02640	.00150	.00005	28,500,000
15,000	.02533	.00043		26,200,000	58,000	.02645	.00155	.00005	28,000,000
16,000	.02539	.00049	.00006	24,500,000	59,000	.02650	.00160	.00005	27,600,000
17,000	.02539	.00049		26,000,000	60,000	.02655	.00165	.00005	27,300,000
18,000	.02544	.00054	.00005	25,000,000	61,000	.02659	.00169	.00004	27,000,000
19,000	.02544	.00054		26,400,000	62,000	.02664	.00174	.00005	26,700,000
20,000	.02544	.00054		27,800,000	63,000	.02669	.00179	.00005	26,400,000
21,000	.02550	.00060	.00006	26,300,000	64,000	.02674	.00184	.00005	26,100,000
22,000	.02550	.00060		27,500,000	65,000	.02674	.00184		26,400,000
23,000	.02550	.00065	.00005	26,500,000	66,000	.02678	.00188	.00004	26,300,000
24,000	.02550	.00065		27,700,000	67,000	.02680	.00190	.00002	26,400,000
25,000	.02550	.00065		28,900,000	68,000	.02683	.00193	.00003	26,500,000
26,000	.02560	.00070	.00005	27,800,000	69,000	.02684	.00194	.00001	26,600,000
27,000	.02560	.00070		28,900,000	70,000	.02686	.00196	.00002	26,800,000
28,000	.02560	.00070		30,000,000	71,000	.02687	.00197	.00001	27,000,000
29,000	.02566	.00076	.00006	28,600,000	72,000	.02687	.00197		27,400,000
30,000	.02566	.00076		29,600,000	73,000	.02687	.00197		27,800,000
31,000	.02566	.00076		30,600,000	74,000	.02692	.00202	.00005	27,500,000
32,000	.02572	.00082	.00006	29,300,000	75,000	.02696	.00206	.00004	27,300,000
33,000	.02577	.00087	.00005	28,400,000	76,000	.02701	.00211	.00005	27,000,000
34,000	.02583	.00093	.00006	27,400,000	77,000	.02705	.00215	.00004	26,800,000
35,000	.02588	.00098	.00005	26,800,000	78,000	.02710	.00220	.00005	26,600,000
36,000	.02588	.00098		27,500,000	79,000	.02714	.00224	.00004	26,400,000
37,000	.02588	.00098		28,300,000	80,000	.02718	.00228	.00004	26,300,000
38,000	.02594	.00104	.00006	27,400,000	*95,150				
					* Breaking Load				

No. 4

BURMESE JADEITE — LOADS AND CORRESPONDING DEFORMATIONS — AREA, .7634 SQ. IN.

Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity	Applied loads in lbs. per sq. in.	Compressometer readings in inches	Change of length in inches		Modulus of elasticity
		Actual	Difference				Actual	Difference	
500	.01120				28,000	.01174	.00054	.00004	38,900,000
1,000	.01130	.00010		7,500,000	29,000	.01174	.00054		40,200,000
2,000	.01134	.00014	.00004	10,700,000	30,000	.01178	.00058	.00004	38,800,000
3,000	.01137	.00017	.00003	13,200,000	31,000	.01178	.00058		40,000,000
4,000	.01137	.00017		17,600,000	32,000	.01182	.00062	.00004	38,700,000
5,000	.01141	.00021	.00004	17,900,000	33,000	.01182	.00062		39,900,000
6,000	.01141	.00021		21,400,000	34,000	.01182	.00062		41,100,000
7,000	.01145	.00025	.00004	21,000,000	35,000	.01186	.00066	.00004	39,800,000
8,000	.01149	.00029	.00004	20,700,000	36,000	.01190	.00070	.00004	38,600,000
9,000	.01149	.00029		23,200,000	37,000	.01190	.00070		39,600,000
10,000	.01149	.00029		25,800,000	38,000	.01190	.00070		40,700,000
11,000	.01153	.00033	.00004	25,000,000	39,000	.01194	.00074	.00004	39,500,000
12,000	.01153	.00033		27,300,000	40,000	.01194	.00074		40,500,000
13,000	.01153	.00033		29,600,000	41,000	.01198	.00078	.00004	39,400,000
14,000	.01153	.00033		31,800,000	42,000	.01198	.00078		40,400,000
15,000	.01153	.00033		34,100,000	43,000	.01198	.00078		41,700,000
16,000	.01153	.00033		36,400,000	44,000	.01202	.00082	.00004	40,300,000
17,000	.01157	.00037	.00004	34,500,000	45,000	.01202	.00082		41,200,000
18,000	.01157	.00037		36,500,000	46,000	.01207	.00087	.00005	39,600,000
19,000	.01157	.00037		38,500,000	47,000	.01211	.00091	.00004	38,700,000
20,000	.01161	.00041	.00004	36,600,000	48,000	.01211	.00091		39,600,000
21,000	.01166	.00046	.00005	34,300,000	49,000	.01216	.00096	.00005	38,300,000
22,000	.01166	.00046		35,900,000	50,000	.01216	.00096		39,000,000
23,000	.01166	.00046		37,500,000	51,000	.01216	.00096		39,800,000
24,000	.01166	.00046		39,100,000	52,000	.01216	.00096		40,600,000
25,000	.01166	.00046		40,700,000	53,000	.01220	.00100	.00004	39,700,000
26,000	.01170	.00050	.00004	39,000,000	54,000	.01238	.00118	.00018	34,300,000
27,000	.01170	.00050		40,500,000	*55,000	.01328	.00208	.00090	19,800,000

* Breaking Load

Amount of Deformation.—On comparing the columns of "Differences" in the tables given above, it will be noted that the amount of compression for each additional load of 1000 pounds per square inch of area was very uniform throughout the whole set of tests. With few exceptions, the maximum variation for the whole four hundred observations taken was about 0.0001 of an inch, and the majority of the variations were within 0.00003 of an inch. This uniformity is slightly more apparent in the tests of nephrite than in jadeite.

In many instances, particularly with the jadeite, several increments of load would be added before any additional increase in deformation would be observed. In this respect it was more erratic than the nephrite. However, considering the very small value of these measurements and the fact that the specimens were not duplicates, the results are really quite wonderful. Attention must also be called to the fact that all the variation recorded is not due to deformation of the specimen. A certain proportion must be charged to unavoidable errors in reading the instrument, and a considerable portion to errors in the instrument itself. The Olsen compressometer used was the only one obtainable suited for so short a gauged length as $\frac{3}{4}$ of an inch. It read directly to $\frac{1}{10000}$ (0.0001) of an inch, and smaller values were estimated. The instrument was not as accurate as claimed by its maker, though by carefully standardizing, and obtaining its errors for the range over which it was used, it was possible, by applying corrections, to get quite accurate observations. An initial load of 500 to 1000 pounds per square inch was applied before readings were begun, and most of the records are not to be fully depended upon until a load of 2500 pounds per square inch has been reached. By that time specimen and instrument have settled to a rigid bearing and the readings become logical.

The total amount of compression, as expressed in percentage of the gauged length of $\frac{3}{4}$ of an inch, is also quite uniform. On the four specimens where measurements were obtained at loads of 75,000 pounds per

square inch, the amounts of compression were practically $\frac{3}{10}$, $\frac{4}{10}$, $\frac{5}{10}$, and $\frac{5}{10}$ of one per cent.—a variation of only $\frac{2}{10}$ of one per cent. in all. With the two jadeites from Burma, which broke at 40,000 pounds and 55,000 pounds per square inch respectively, measurements made at 40,000 pounds per square inch on each give exactly the same amount of compression—viz., $\frac{1}{10}$ of one per cent.

Numerous attempts were made to determine if permanent set remained after the application and removal of certain definite loads, but the amounts were so small, if any really existed, that they were beyond the capacity of the instrument to measure accurately, so the plan was abandoned.

Specimens Nos. 7, 96, and 162 were measured laterally while sustaining a load of 75,000 pounds per square inch, and these dimensions were found to have increased in proportion as the vertical dimensions had decreased. With one exception (which may have been an error in reading), this expansion in each direction was from $\frac{1}{2}$ to $\frac{2}{3}$ of the total compression.

Elastic Limit.—With the possible exceptions of Nos. 4 and 15, none of the specimens showed any clearly defined elastic limit under the loads for which deformations were measured. The two exceptions crushed before the instrument was removed, so deformation readings were taken up to the point of failure. In these two instances there is a large increase in the amount of compression just previous to failure (see Plate of Stress-Diagrams) that would seem to indicate an elastic limit, though the point is so near the breaking load that it is quite probable that final disintegration had begun.

Modulus of Elasticity.—The modulus of elasticity was calculated for each deformation measured. In computing this the well-known formula $E=\frac{p}{d}$ was employed, in which E=modulus, p=unit load, d=unit deformation. It will be observed from the tables that the modulus of elasticity has a marked variation for the different specimens, and for different loads on the same specimen, but this is to be expected with such material. It is well known that the modulus of elasticity of stone is quite variable, and increases with increase of load over quite large ranges of application, often differing by several millions in value. This characteristic is very marked in these tests, but as a whole the results are surprisingly regular when one takes into consideration the widely varying character of the specimens and the very small length measured, because of which a slight variation in the fourth decimal place of measurement would make a difference of hundreds of thousands in calculating the value of the modulus.

The varying value of the modulus for each specimen is clearly shown in the accompanying diagram, where all the moduli for each test were plotted to scale, and the average curves drawn.

In all cases, the modulus gradually increased with the load; sometimes this continued to the point where the instrument was removed, as in the nephrite from China, No. 96; sometimes it rose to a maximum and practically held there, with moderate fluctuations, for some time, then reduced slightly as in the case of the New Zealand nephrite No. 162, and the Chinese (Turkistan) nephrite No. 97, while in the case of the Burmese jadeite No. 7 it rose to a maximum in the same way, then took a decided fall with gradual regularity.

The two jadeites from Burma, No. 4 and No. 15, both crushed while the compressometer was still attached, and they both show a sharp falling off of the modulus during the application of the last few thousand pounds of load. This was undoubtedly due to incipient failure of the specimen. The former (No. 4) gives a very regular curve, but the curve of the latter (No. 15) is exceedingly erratic in its character, for which no cause is apparent. It is probably due to errors in reading the instrument.

The most remarkable feature of these figures, and the one which shows more clearly than anything else the wonderful tenacity and elasticity of this rare mineral, is the very high value which the modulus attains.

The minimum value is 3,000,000 and the highest 47,000,000. Four specimens gave a maximum of over 30,000,000, and for No. 96 (the lowest record) the maximum was 15,000,000. The extraordinary character of these figures will be best understood by reference to the adjoining table, giving the approximate values of the modulus of elasticity for various well-known materials as determined by United States Government tests:

Steel,	28,000,000 to 30,000,000	Granite,	2,000,000 to 9,000,000
Cast Iron,	12,000,000 " 27,000,000	Limestone,	3,000,000 " 5,000,000
Marble,	6,000,000 " 14,000,000	Sandstone,	1,000,000 " 5,000,000
Blue Stone,	4,000,000 " 9,000,000	JADE,	3,000,000 " 47,000,000

The figures given for stone are considerably higher than those given by Professor Bauschinger from investigations on Bavarian stone.

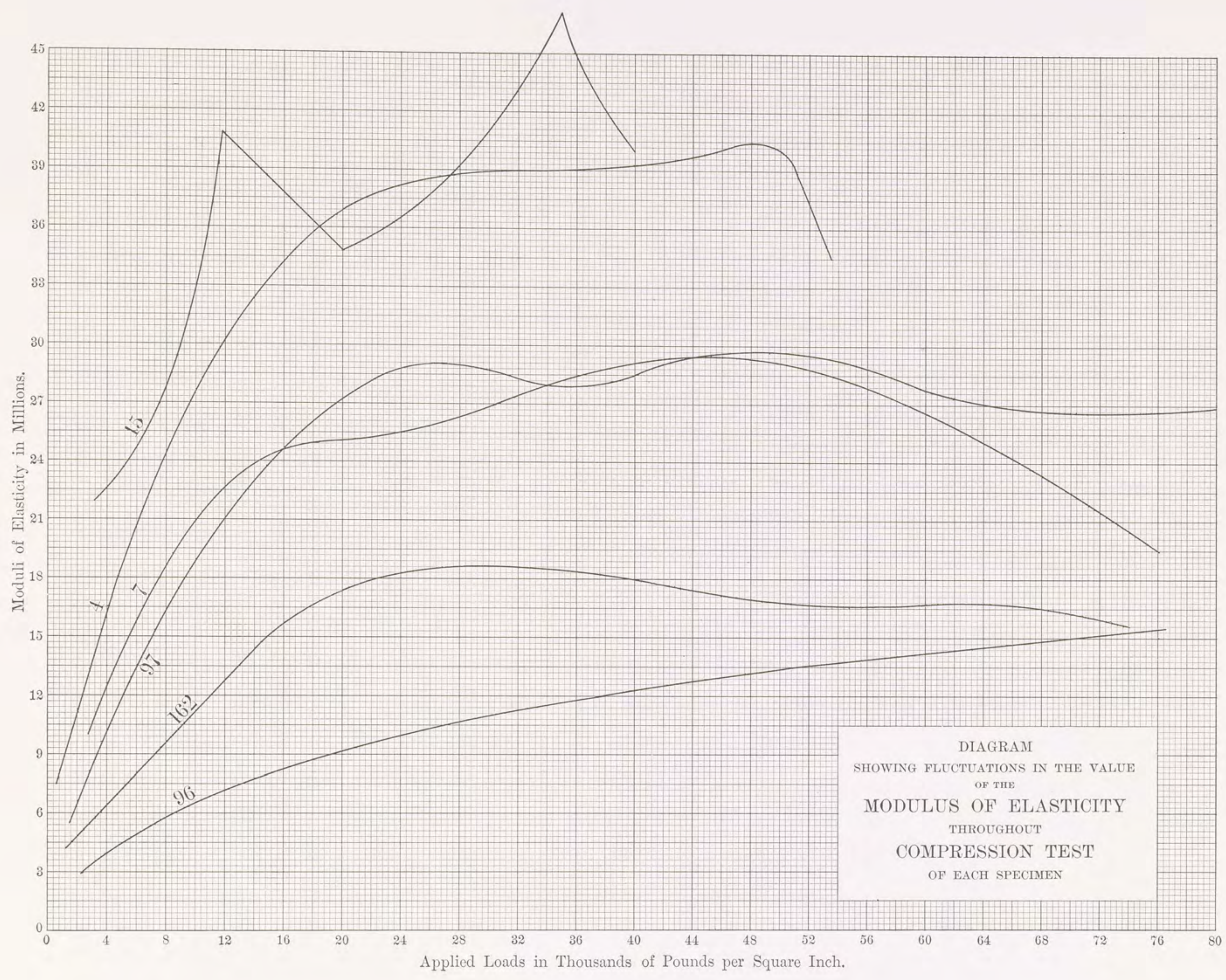
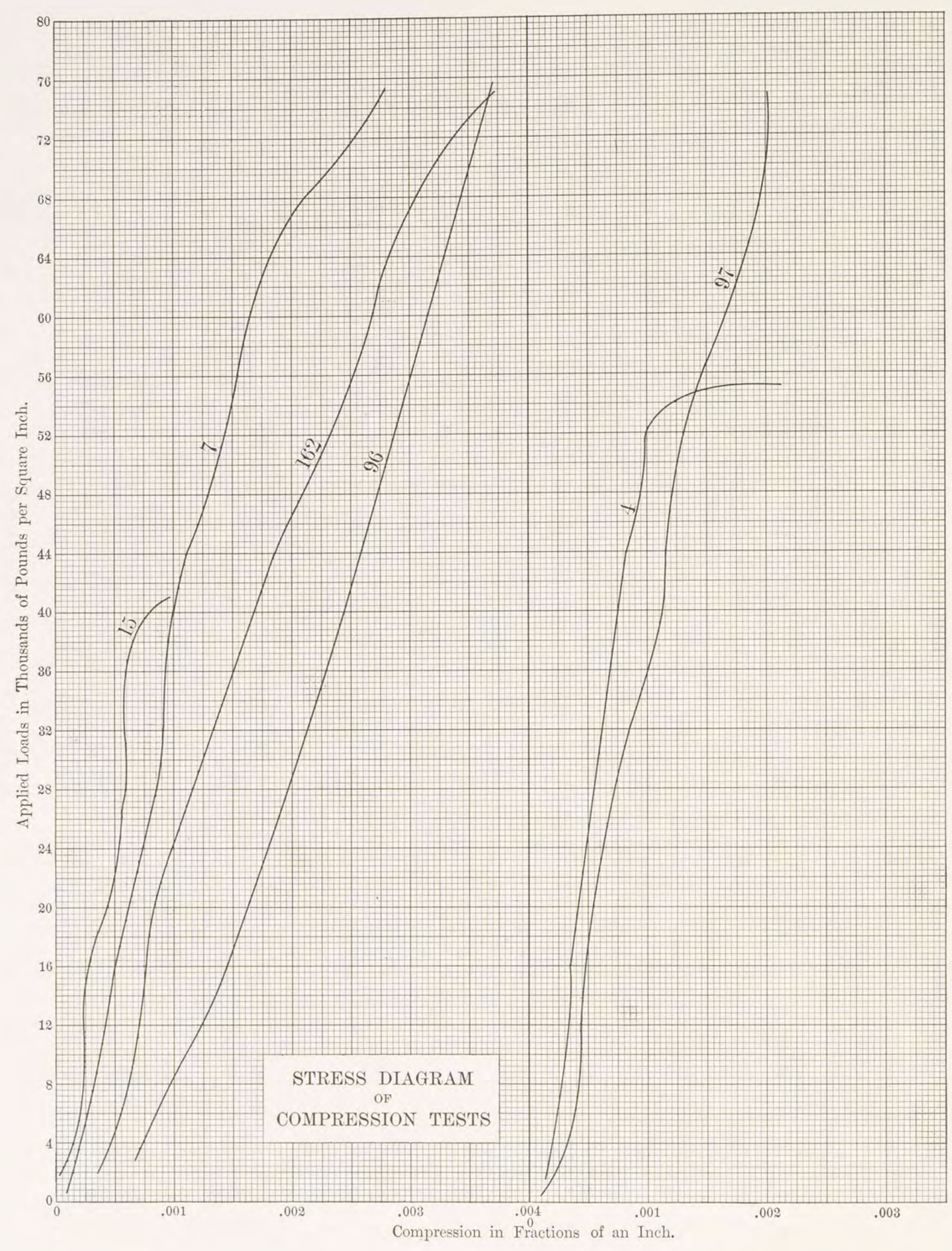
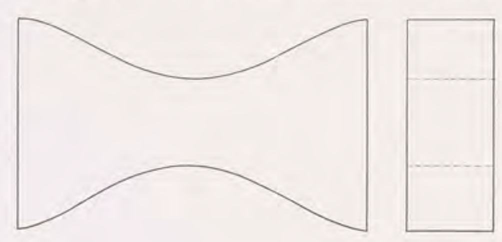


DIAGRAM
SHOWING FLUCTUATIONS IN THE VALUE
OF THE
MODULUS OF ELASTICITY
THROUGHOUT
COMPRESSION TEST
OF EACH SPECIMEN
Moduli of Elasticity in Millions.
Applied Loads in Thousands of Pounds per Square Inch.
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
15
1
7
95
162
96



STRESS DIAGRAM
OF
COMPRESSION TESTS
Applied Loads in Thousands of Pounds per Square Inch.
Compression in Fractions of an Inch.
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
.001
.002
.003
.004
.001
.002
.003
15
7
162
96
4
97

TENSION TESTS



These also were made by Professor Woolson with the same Emery hydraulic testing-machine, and on specimens of the carefully selected and typical material already described as having been used in the other tests—viz.: No. 7, jadeite from Burma; No. 96, nephrite from China; No. 162, from New Zealand; No. 130, from Siberia; Nos. 67, 78, and 79, from Chinese Turkistan; and No. 134*a*, from Jordansmühl, Silesia. Only one specimen of each was tested. They were of the shape and size shown in the annexed diagram.

The results are here tabulated:

	I	II	III	IV	V	VI	VII	VIII
Material	Jadeite	Nephrite	Nephrite	Nephrite	Nephrite	Nephrite	Nephrite	Nephrite
Source	Burma	China	New Zealand	Turkistan	Siberia	Turkistan	Jordansmühl	Turkistan
No. on specimen	7	96	162	79	130	78	134*a*	67
Thickness	.570 in.	.505 in.	.517 in.	.505 in.	.508 in.	.508 in.	.519 in.	.505 in.
Average width at fracture	.564 in.	.540 in.	.700 in.	.770 in.	.593 in.	.746 in.	.537 in.	.534 in.
Area of fracture	.265 sq. in.	.270 sq. in.	.362 sq. in.	.389 sq. in.	.301 sq. in.	.379 sq. in.	.279 sq. in.	.270 sq. in.
Maximum load	1340 lbs.	1620 lbs.	1970 lbs.	1000 lbs.	820 lbs.	880 lbs.	810 lbs.	1490 lbs.
Strength per square inch	5056 lbs.	5959 lbs.	5442 lbs.	2570 lbs.	2724 lbs.	2321 lbs.	2903 lbs.	5518 lbs.
Character of fracture	Square across	Somewhat ragged and at an angle	Quite irregular and ragged	Square across at ½ inch from smallest section	Square across at ⅛ inch from smallest section	Slanting along cleavage plane about ½ inch from smallest section	Square across the smallest section	Square across the smallest section
Time of test	10 min.	8 min.	11 min.	Averaged from 8 to 15 minutes				

Remarks:—Seams in structure of Nos. 96 and 162 turned white when nearing the maximum load.
At a pull of 1920 lbs. the first crack occurred in No. 162, and the specimen opened on one side.
Slight flaw or cleavage was observable in No. 78 before test, beginning at and running up one side.

The figures are very uniform, but are in no way as striking as the compression tests. The specimens were so short that it was impossible to attach an instrument for measuring the deformation, so the ultimate strength was the only result obtained.

The great cohesive power of jade is very clearly shown by these tests of Woolson and Page. It is this wonderful resistance to stresses of every kind which conduces to the enduring quality of the mineral and makes it possible to carve it into the most delicate forms and impart to it such a high polish. Crystals of diopside, tremolite, and actinolite, the equivalents of the jade minerals in composition and hardness, possess none of the great tenacity which isolates nephrite and jadeite. After what has been said above, however, under the head of Structure, it is not difficult to understand that this great difference in cohesiveness is to be traced to the fibrous character of jade, the individuals which compose the mass being so compactly felted, woven, and twisted together that the whole possesses a power of resistance to fracture or to cutting far above that of the individuals themselves.

It is said of nephrite, as of almost every rock or mineral that is mined, that when first taken from the mine it is susceptible of being much more readily worked than later. There is a possibility that while it still contains a little quarry-water it may be a trifle more readily worked, but this has never been proved. Indeed, it is the difficulty of quarrying jade that impels the quarrymen of Burma to resort to the use of fire in detaching the jade mass from its bed. This difficulty was well illustrated in the writer's experience at the Jordansmühl quarry in April, 1899, when an attempt was made by drilling and blasting to remove the large block of nephrite, weighing 2140 kilogrammes, now in the Collection. After a few blows on the head of the drill the point became blunted, much to the surprise of the workmen, and the blasting had to be abandoned.

FRACTURE

The fibrous structure which gives to the jade minerals their exceptional tenacity is again expressed in their mode of fracture. Both jadeite and nephrite possess a very perfect cleavage parallel to the prismatic planes of their crystals; but, as a rule, the individuals are so small in both minerals that these cleavages are imperceptible and the fracture surface is very uneven, splintery, and as though dusted over with minute slivers of the substance, the roughness being readily felt if the finger be drawn across the surface. It may best be likened to the surface of broken horn.

This type of fracture is, however, particularly characteristic of nephrite. The more granular jadeite, especially that of coarser grain, breaks with a distinctly granular fracture often not unlike that of marble—the cleavage of each grain being visible in the numerous glistening facets that stud the surface. But even this granular fracture-surface is more or less rough and splintery, thus testifying to the tenacity with which the particles cling to one another.

HARDNESS

Hardness, or the degree to which a substance resists abrasion, is one of the simplest and one of the most practical means of distinguishing minerals, and especially in distinguishing jadeite from nephrite. It has been found that the hardness of pure nephrite is quite constant at 6.5 of the Mohs scale, or that of microcline feldspar—*i. e.*, it can be scratched by quartz, but will not scratch quartz; whereas jadeite when pure is very constant at 7 (the hardness of rock-crystal), but it can be scratched by agate or chalcedony, which are a trifle harder than the crystalline varieties of quartz (rock-crystal and amethyst). Consequently jadeite will scratch nephrite, especially when it is polished. If, therefore, a slab of polished nephrite be plainly scratched by a jade mineral, the latter cannot be nephrite and may be classed as jadeite. This, however, is true only of pure jadeite and pure nephrite. Errors may arise from the admixture of other minerals in greater or smaller quantities. In some pieces these can be detected by the naked eye, or with the aid of a pocket lens, but can most surely be detected and identified by microscopic examination of thin sections.

The hardness, according to the Mohs scale, of every piece in the Collection was determined by the present writer, by the methods common among mineralogists, and by means of finely pointed triers made of the following minerals:

Topaz, with a hardness of 8
Quartz, with a hardness of 7
Microcline feldspar, with a hardness of 6.5
Orthoclase feldspar, with a hardness of 6
Apatite, with a hardness of 5

To corroborate the results thus obtained and for purposes of comparison, a set of four additional triers was made from typical pieces of jadeite and nephrite in the Collection. These, like the five already mentioned, consisted of small prismatic sections, four to five millimetres in breadth and ten to twenty millimetres in length, pointed at each end. They were as follows:

No.	1—143	Crude	nephrite	from	Silesia,	Hardness	6.5	Mohs scale
"	2—162	"	"	"	New Zealand,	"	6.5	" "
"	3— 4	"	jadeite	"	Burma,	"	7	" "
"	4— 32	"	"	"	"	"	7	" "

The triers were held firmly in the hand and then steadily drawn across the specimen to be tested for a distance of usually not more than two to five millimetres. The trier of the lowest hardness was first used, and then the next higher in regular succession until a scratch could be obtained; and, owing to the extreme fineness of the points, so delicate was this scratch that it was scarcely discernible by the naked eye. Indeed, in many cases it was necessary to use a pocket lens. In almost every instance the result was obtained with little difficulty, for even the mineralogical pieces had been polished on one side to show more clearly the color of a polished surface as well as that of the natural fracture or cleavage, and every archæological object had either a polished or a smooth surface. Nephrite was not affected by orthoclase feldspar (unless part of it was decomposed), it was scarcely marked by microcline feldspar, but could readily be scratched by quartz. Jadeite was not affected by microcline feldspar, scarcely by quartz, but markedly by chalcedony and agate points, which, although quartz, are slightly harder; and of course the jadeite of Burma scratched the nephrite from Silesia, Siberia, and New Zealand.

SPECIFIC GRAVITY

The density, or specific gravity, of jade offers a comparatively simple problem for study. In jadeite we have a pyroxene, and in nephrite a member of the parallel amphibole series. In general terms, other factors being equal, the pyroxenes are higher in specific gravity than the amphiboles, and the difference is well beyond the range of experimental errors. The mean density of nearly five hundred nephrites, according to the figures given elsewhere, is 2.95+. That of about one hundred jadeites is 3.32+, and that of six chloromelanites is 3.40+. Chloromelanite is essentially a jadeite containing a larger proportion of iron compounds, and to that cause mainly its higher specific gravity is due. The table which is given farther on well shows the range of variation in each group of jade.

The determination of the density, or specific gravity, of every piece in the Collection that was not inseparably mounted in wood or metal was kindly undertaken by Professor William Hallock, of the Department of Physics in Columbia University, New York; and his account of the methods, and of the special devices employed by him, is here given in full.

The determination of the density of a large number of such objects as are brought together in this wonderful Collection of Jades, and especially of large, finely sculptured pieces, presents two problems of novel interest: first, the handling of a single piece weighing as much as sixty kilogrammes (one hundred and thirty-two pounds), several weighing from five to fifteen kilogrammes, and, secondly, a very large number of smaller articles.

Apparently no one has heretofore attempted to determine, by immersion, the density of an object weighing more than a few pounds, and indeed there has been little or no necessity for such a determination, since it is but rarely that a heavier specimen is sufficiently homogeneous to make its density of interest, and if it were, a piece could be knocked off for examination; but one cannot knock off a piece of an absolutely unique carved jade jardinière.

For the examination of the heavy articles a Kohlbusch bullion balance of thirty kilogrammes (one thousand ounces) capacity was used; two other Kohlbusch balances for moderate load, and a Becker analytical balance, were employed for the smaller articles, as the case required. For the great jardinière, with its mass of sixty kilogrammes, double the load of our largest balance, a special device had to be invented. It consisted of an auxiliary lever, or balance-arm, having three parallel steel knife-edges, one under each end and one on top about one fourth the length from one end. The knife-edge under the short end rested upon a plate of glass mounted upon a wooden trestle, the knife-edge under the long end of the bar resting upon a plate of glass lying on the centre of the left-hand scale-pan. Upon the third knife-edge rested a plate of glass under a yoke, from which depended a hook upon which the object to be weighed could be hung. By placing a ten-kilogramme weight upon this hook it was possible to weigh the pressure upon the scale-pan and thus determine accurately the ratio of the lever arms. Hanging the jardinière upon the hook, its weight in air was observed, and then, placing around it a tank of water, it was possible to determine its weight when immersed in water, these two weights enabling one to calculate the density. The system is more efficient and convenient when the vertical plane through the balance beam and that through the auxiliary beam are approximately at right angles to each other.

The other pieces of over one kilogramme mass were placed upon the pan of a suitable balance and weighed, one after another. Then, replacing the ordinary pan of the balance with a skeleton pan hanging upon a single fine wire in a tank of water, the same articles were weighed in water.

A great number of the articles under one kilogramme in mass (over five hundred) were determined upon a special form of balance constructed for the work. The left pan was removed and in its stead was placed a two-story pan; the upper one hanging directly on the beam, and the lower one hanging by a single fine wire from a hook under the upper pan. The lower pan was entirely submerged in a jar of water, only the suspending wire passing through the surface. Under these conditions the balance is counterpoised and adjusted and is then ready for the day's use. It must, however, be readjusted from time to time, on account of the varying temperature and level of the water. This arrangement is very convenient and enables one to

determine densities very easily, rapidly, and withal accurately. The object is placed in the upper pan and weighed in air, then upon the lower pan and weighed in water, and all is finished. In the latter part of the investigation a similar two-story pan was fitted to all the balances. Any difficulty arising from the capillary action of the surface of water where the wire passes through is readily eliminated by making small waves on the water; for example, by tapping on the tank or by putting the tip of the finger into the water while the weighing is going on.

In all cases the article was first wetted with alcohol, then washed in an auxiliary tank of water, and then placed on the lower pan in the weighing-tank; in this way it was possible to ensure perfect wetting and the entire elimination of all air films and bubbles. In certain special cases where the article was slightly porous, it was weighed in water several times after periods of soaking ranging from a few hours to several days. The formula used to calculate the results is the usual one to be found in any reliable text-book:

$$D = \frac{M}{W}(Q - L) + L,$$

in which D is the density or specific gravity.
M is the apparent weight of the body in air.
W is the apparent loss in weight of the body when suspended in water.
Q is the density of the water in which the object is weighed.
L is the density of the air at the temperature and barometic pressure existing during the weighings. In practice it is sufficiently accurate to assume $L = 0.0012$.

This formula is rigidly correct, and allows for the buoyant effect of the air upon the weights as well as upon the object.

The object is weighed in air, and this weight is M; it is then weighed while submerged in water whose temperature is noted; this weight in water subtracted from the weight in air gives W, the loss in weight due to the buoyant effect of the water; Q is obtained from a table giving the density of water at different temperatures.

The specific gravity of over one thousand separate pieces, with a density of 2.9 and over, was determined by Professor Hallock. The figures given below are based on the first five hundred and ninety-eight of these, and may be accepted as typical of all.

Of the five hundred and ninety-eight specimens six were chloromelanites; one hundred and one, jadeites; four hundred and ninety-one, nephrites.

From 2.9 up to 3.0	417 pieces averaged	2.9389 (nephrite)	From 3.2 up to 3.34	101 pieces averaged	3.3152 (jadeite)
" 3.0 " " 3.2	74 " "	3.0159 (nephrite)	" 3.34 upward	6 " "	3.4039 (chloromelanite)

Taking the nephrites all together, the average is 2.9505; the jadeites and chloromelanites together show an average of 3.3202.

Jadeites.		*Jadeites.*	
6 chloromelanites average 3.4039		8 pieces have a specific gravity of 3.31 +	(average 3.3182)
43 pieces have a specific gravity of 3.33 +	(average 3.3351)	4 " " " " 3.30 +	(" 3.3041)
27 " " " " 3.32 +	(" 3.3252)	19 " " " " 3.20 +	(" 3.2527)
Nephrites.		*Nephrites.*	
3 pieces have a specific gravity of 3.10 +	(average 3.1311)	145 pieces have a specific gravity of 2.95 +	(average 2.9545)
71 " " " " 3.00 +	(" 3.0109)	65 " " " " 2.94 +	(" 2.9461)
34 " " " " 2.99 +	(" 2.9945)	24 " " " " 2.93 +	(" 2.9356)
28 " " " " 2.98 +	(" 2.9843)	4 " " " " 2.92 +	(" 2.9256)
45 " " " " 2.97 +	(" 2.9748)	1 " " " " 2.91 +	(" 2.9171)
69 " " " " 2.96 +	(" 2.9642)	2 " " " " 2.90 +	(" 2.9035)
491 nephrites average 2.9505			

When we study the individual specimens in detail, many differences of density appear; but in most cases they are easily intelligible. In the less pure jadeites and in all the nephrites we have to deal with salts of lime and magnesia, which replace each other in varying proportions. An increase in magnesia tends to

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No. 444

ELEPHANT CARRYING VASE

(*T'o P'ing Hsiang*)

K'ang-hsi (1662–1722)

Nephrite

raise density, and an increase in lime to lower it. If, however, the lime in a specimen represents a pyroxene, the density will be higher than in an amphibole of similar composition. Iron increases density very perceptibly; water, on the other hand, is a depressing agent. Again, an admixture of a lighter mineral diminishes specific gravity; as in No. 4, a mixture of jadeite and analcite of density 3.2176, and in No. 303, a jadeite and albite mixture of density 2.8345. In short, the specific gravity of a given sample depends upon many factors, which often operate in different directions; but as we approach the typical minerals in their greatest purity remarkably constant and uniform values appear. The statistical table shows how close the determinations run together, and indicates a remarkable uniformity in this particular. In most cases density alone will distinguish between jadeite and nephrite, but the first species contaminated by a lighter impurity may even fall below a nephrite which happens to be rich in iron.

THE SONOROUSNESS OF JADE

The resonant character of jade has long been known to the Chinese, and regarded by them as a sure sign of the genuineness of the material, when found united with translucency and the proper color. "Sounding-stones," and stones for polishing them, are mentioned in the earliest historical records of China—twenty-three centuries B.C.—as tribute to be furnished by certain provinces, after the waters of the great Chinese flood had been regulated and drained off by Yü the Great, and the empire resurveyed by him.[1]

Confucius played on the "musical stone," and we find frequent reference to it in the early classical literature of the country. "Full indeed is the heart of him who beats the musical stone like that" was the remark of a passing peasant as Confucius, the sage, and disappointed reformer, then a sojourner in the principality of Wei, sought solace in the tinkle of the sounding-stone as he bewailed the degeneracy of his times and the non-success of his teachings.

The "Book of Poetry," a collection of odes ranging in date from 1765 B.C. to the sixth century B.C., refers to the "musical stone" in connection with the mouth-organ, the flute, and the drum; and in one of the odes, whose theme was ceremonial music, we are told that

> When the bells and drums sound in harmony
> And the sounding-stones and flutes blend their notes,
> Abundant blessing is sent down.

These musical stones were of various kinds:

(1) The "single stone," used "to receive the sound" at the end of a line, as in chanting a ceremonial hymn.
(2) A series of sixteen, all of the same size and shape, but differing in thickness, forming the "stone chime," used in court and religious ceremonies.
(3) A series of twelve to twenty-four pieces, carved into fantastic shapes, forms what is called the "singers' chime."

Jade was the material best adapted for musical uses, but we are told in the books that other stones were also in use, especially a kind of black calcareous stone which was more easily worked than jade.[2]

The common form of the musical stones composing the stone chime is that of an undecorated obtuse-angled carpenter's square with unequal arms, the longer—that usually beat—measuring 1.8 feet, and the shorter, 1.35 feet.

The Collection includes several specimens of the decorated kind. Two of these (Nos. 421 and 646) and a number of bowls and other objects, twenty-one in all, were selected for a series of special sound-tests by Professor Hallock of Columbia University, and his report, preceded by a description of the specimens tested, is now given in full.

[1] See the Shoo King, Vol. III, part i, p. 121, in Legge's Chinese Classics (London and Hongkong, 1865).
[2] See Chinese Music, by J. A. Van Aalst, published by the Imperial Maritime Customs of China (Shanghai, 1884).

TWENTY-ONE JADE OBJECTS TESTED FOR SONOROUSNESS

Number 446. A graceful ju-i sceptre of beautifully compact and pure nephrite, 46.4 centimetres long, 11 centimetres broad, and 1.3 centimetres thick; weight, 33.792 ounces; specific gravity, 2.9620; broad oval head of four-lobed outline, carved in relief; an incised inscription on the stem.

Numbers 422. 423. A pair of plain rice-bowls of jadeite, 8 centimetres in height and 17.2 centimetres in diameter; specific gravity of No. 422, 3.3364; of No. 423, 3.3376; weight of No. 422, 12.617 ounces; weight of No. 423, 14.873 ounces.

Number 488. A bowl of remarkably pure jadeite, carved in slight relief, and known as a "camphor bowl" because of its resemblance in color and texture to lump-camphor, showing a translucent ground, thickly interspersed with clouds of opaque white. Height, 5.5 centimetres; diameter, 16.5 centimetres; weight, 11.415 ounces; specific gravity, 3.3374. It is so translucent in parts that print in contact with it can be read through it.

Number 763. A small circular fluted dish of translucent, homogeneous, and compact nephrite, modelled after the conventional chrysanthemum pattern; 3.5 centimetres in height and 16.6 centimetres in diameter; weight, 7.591 ounces; specific gravity, 2.9673.

Number 692. A rice-bowl of remarkably fine-grained, translucent, homogeneous, and compact nephrite, with a low foot cut in scallop fashion, and a double band of vertical flutings, convex without and concave within. Height, 5 centimetres; diameter, 12 centimetres; weight, 5.344 ounces; specific gravity, 2.9492.

Number 756. A highly polished nephrite bowl of remarkably pure material and of almost egg-shell thinness, fluted into eight slightly bulging lobes, and poised upon a circular rimmed foot, and provided with handles carved in openwork with a spiral ornament. Height, 5.7 centimetres; diameter, 13 centimetres; weight, 6.204 ounces; specific gravity, 2.9506.

Number 489. A small tea-cup of exceedingly pure and transparent jadeite, with a circular rim round the foot and a slightly etched design on the outside. Height, 4.5 centimetres; diameter, 10.5 centimetres; weight, 3.152 ounces; specific gravity, 3.3374.

Number 701. A small polished bowl without decoration or carving except an incised inscription underneath. The material is nephrite, translucent, compact, and remarkably homogeneous in its texture. Height, 6.5 centimetres; diameter, 14.3 centimetres; weight, 10.293 ounces; specific gravity, 2.9809.

Number 695. A small round saucer-like dish with three rings of flutings surrounding a convex button-shaped middle engraved with cross-lines. The nephrite is translucent, very compact and homogeneous, with inclusions of a black metallic substance—probably chromite. Height, 3.5 centimetres; diameter, 15.9 centimetres; weight, 7.216 ounces; specific gravity, 2.9915.

Number 697. A round saucer-like dish, finely fluted in three concentric rings encircling a round, nearly flat, cross-hatched centre. The nephrite is translucent, and very hornlike in its general texture. Height, 3.8 centimetres; diameter, 16.1 centimetres; weight, 7.415 ounces; specific gravity, 2.9968.

Number 642. A large round dish of flattened saucer-like form, plain inside but covered outside with a carved decoration in slight relief. The nephrite is translucent, homogeneous, and compact, and shows a number of inclusions. Height, 2.5 centimetres; diameter, 27.6 centimetres; weight, 20.024 ounces; specific gravity, 2.9757.

Number 806. A shallow undecorated bowl, with flat base, of translucent, homogeneous, and compact Siberian nephrite. Height, 3.3 centimetres; diameter, 12.2 centimetres; weight, 5.425 ounces; specific gravity, 3.0154.

Number 414. A large flaring bowl, with circular rimmed foot, of the variety of nephrite styled "pudding-stone jade." Height, 7.3 centimetres; diameter, 20.3 centimetres; weight, 17.448 ounces; specific gravity, 3.0034.

Number 492. A large round saucer-shaped dish, of conventional chrysanthemum design, carved out of the "melting snow enclosing bits of moss" variety of jadeite, so called from its general aspect. It is carved outside with a double ring of flutings, and inside with six concentric rings of florets or petals. Height, 4.7 centimetres; diameter, 29.4 centimetres; weight, 50.116 ounces; specific gravity, 3.3363.

Number 767. A large undecorated bowl of nephrite, which shows a marked horizontal stratification, as indicated by numerous inclusions of a black metallic mineral—probably chromite. Height, 9.2 centimetres; diameter, 16.8 centimetres; weight, 12.429 ounces; specific gravity, 2.9499.

Number 495. A jadeite rice-bowl of beautifully translucent, homogeneous, and compact texture, and so thin that print can be read through it at a distance of three to four millimetres. The color is somewhat poetically but accurately described as suggesting "bits of moss enclosed in melting snow." Height, 7.75 centimetres; diameter, 18.45 centimetres; weight, 13.716 ounces; specific gravity, 3.3385.

Number 643. A large round saucer-shaped dish of very translucent, homogeneous nephrite, carved in relief with scrolls on the exterior, and polished to an exquisite thinness. Height, 6.2 centimetres; diameter, 28.5 centimetres; weight, 19.627 ounces; specific gravity, 2.9939.

Number 646. A "musical stone" in the form of a broad obtuse-angled band, carved in relief, with total length of 22.2 centimetres, width of 10.8 centimetres, and thickness of 0.6 centimetre; weight, 9.811 ounces; specific gravity, 2.9787. Translucent and compact nephrite of very sinewy structure.

Number 421. A small carved "musical stone," having the outline of a fish with bowed back, thus approaching the angular shape of a regulation hanging musical stone with unequal arms. Total length, 24 centimetres; breadth, 13.6 centimetres; thickness, 0.9 centimetre; weight, 12.432 ounces; specific gravity, 3.3369. Translucent, homogeneous, and compact jadeite.

Number 805. A finely polished ruler or bar of translucent New Zealand nephrite, of square section; 31.7 centimetres long and 1.25 centimetres thick; weight, 5.008 ounces; specific gravity, 3.0108.

Owing to the high modulus of elasticity and the extreme compactness of jade, it possesses the property of emitting a very clear tone when struck, and of maintaining the tone for a comparatively long time. The tones are of the pure quality usually described as "bell tones," or as "clear as silver," or as "silvery tones." This is undoubtedly due to the fact that the tones are often simple or "pure," unaccompanied by any overtones; in other cases, where the tone is complex, the relation of the partial tones to each other is that of some of the principal harmonious chords, as, for example, the major third-fifth chord (*c e g*), or the same diminished (*c e flat g*), etc.

Owing to a lack of perfect symmetry in either thickness or quality of material, the jades, like bells in general, emit a tone that varies in intensity rhythmically, giving rise to what the physicist calls "beats," and what is called "tremolo" in the organ and the voice, and "throbbing" in bells. If these are not too frequent,—not more than eight or ten per second,—they lend a peculiar charm to the tones; but when they become more rapid they produce a very disagreeable roughness or discord in the tones.

Each of the bowls, plates, saucers, and similar articles might be made the subject of an elaborate acoustic investigation, but the score reproduced later will serve to give an idea of the range and peculiarities of the tones represented.

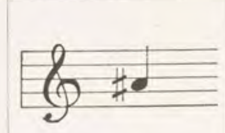
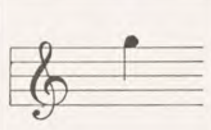
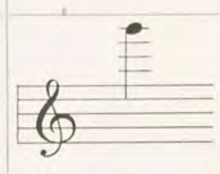
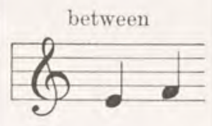
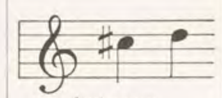
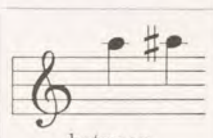
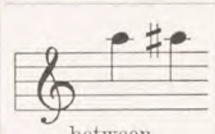
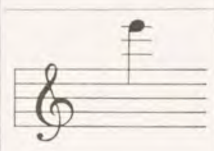
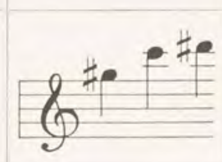
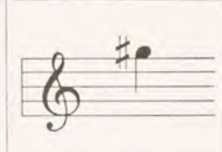
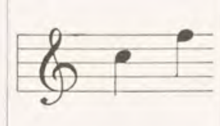
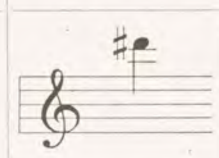
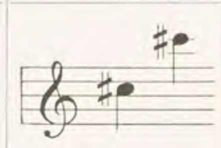
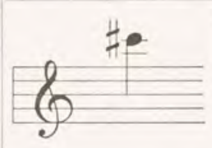
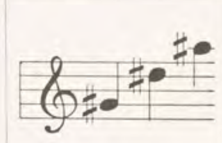
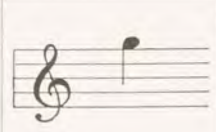
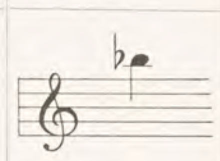
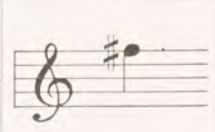
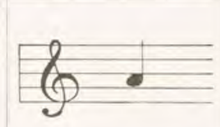
In order to determine the rate of vibration, and possibly the components of the tones, recourse was had to the method of photographing a small gas-flame which was controlled by the motions of the particular bowl or object under study.

Gas, on its way to a small pointed-flame burner, is made to pass through a little box which is provided with a cover of very thin india-rubber. This cover rests against the edge of the bowl, and thus the vibra-

tions of the bowl are transferred to the gas, and thereby to the little flame. The flame is photographed upon a plate that is moving sideways, so that each jump of the flame falls upon a different part of the plate, and the resulting picture looks very much like the teeth of a saw. A similar arrangement resting against a standard electrically driven tuning-fork gives another series of teeth, from which the rate of motion of the plate is computed.

The quality of the tone depends upon the character of the blow, and where it strikes the piece; this is of course due to development of tones higher than the fundamental, either alone or along with the fundamental in varying relative intensities. In these experiments the bowls were struck with a soft wooden hammer, on their extreme edges, the blow being as *staccato* as possible, and the bowl being so supported as not to interfere with its free vibration.

The following table gives the rate of vibration of the fundamental tone, the combination of tones (if present), the number of beats per second, and the duration of the tone after a moderately strong blow.

Number	Position on treble clef	Fundamental vibrations per second	Ratio of tones	Beats per second	Duration of tone	Number	Position on treble clef	Fundamental vibrations per second	Ratio of tones	Beats per second	Duration of tone
446		256	1:2	0	5 seconds	642		456	1	0	12 seconds
423		776	1	0	3 seconds	806		1587	1	0	3 seconds
422	between 	667	1	0	3 seconds	414	 between	562	1	0	4 seconds
488	 between	897	1	3½	6½ seconds	492		810	1	3	5 seconds
763	 between	902	1	4	6 seconds	767		total 1344	4:5	too fast	5 seconds
692		1307	1	0	2 seconds	495		total 1245	4:5:6	3–4	8 seconds
756		809	1	0	5 seconds	643		total 692	3:4	2	18 seconds
489		1216	1	3½	5 seconds	646		total 1126	1:2	0	5 seconds
701		1105	1	4	3 seconds	421		total 908	2:3:4	0	7 seconds
695		768	1	too fast	3 seconds	805		947	[3:5:7:9] theo-retically	0	5 seconds
697		740	1	too fast	2 seconds	Standard of pitch used		435 complete vibrations per second			

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No. 602

ARTIST'S WATER-BOWL

(*Ta Hsi-tzŭ*)

Ch'ien-lung (1736–95)

Nephrite

Ch. Courtry aqua forte

THE CHEMICAL CONSTITUTION OF JADE

A STUDY of the chemical constitution of jadeite and nephrite, by Professor F. W. Clarke, Chief Chemist of the United States Geological Survey, and his deductions given herewith, open up a variety of interesting and curious questions, some of which have a bearing upon problems lying beyond the limits of mineralogy. From Iddings's observations it seems probable that nephrite is sometimes derived from pyroxenes by a process of alteration. He describes, first, jadeites pure and simple; then come jadeites containing traces of amphibole, then with much amphibole, then nephrites containing residual jadeite, then nephrites with the slightest possible remnants of jadeite, and finally nephrite alone. The series is continuous, and in it no sharp breaks appear. Now, as has already been shown, the pyroxenes have higher specific gravity than the corresponding amphiboles. The change from one series to another, therefore, as a consequence of diminished density, implies increase of volume; and this, in the interior of a rock mass, involves the generation of pressure. In other words, the production of the amphibole from the pyroxene takes place under more than the normal pressure of the superincumbent rocks, and it is possible that this fact may account to some extent for the remarkable compactness and tenacity of the product. Another consequence is deducible from the phenomena—namely, that the molecular weight of the pyroxene is greater than that of the amphibole; the one molecule being probably a polymer of the latter. Greater density implies greater complexity of molecule, and the change from one to the other represents a breaking down of the more complex into the simpler. Ordinarily, but on quite superficial grounds, the amphibole molecules have been regarded as heavier than the molecules of pyroxene, but all the valid evidence indicates that the reverse proposition is true. To this subject I shall recur later.

Another class of problems is suggested by the impurities in jade, or rather by its mixture with other minerals. For example, No. 303, a mask from Mexico, is shown by Penfield and Iddings to be a mixture of jadeite and albite. No such mixture has been observed among the Oriental jades, and it therefore becomes more than probable that the Mexican mineral is indigenous. To mineralogists this will seem to be a very simple and obvious matter; but the fact that jadeite has not been reported as found at any Mexican locality *in situ* has led some anthropologists to assume that the American material was derived from an Asiatic source through some prehistoric channel of communication. A fuller study of jadeite from Mexico and Central America might reveal still other differences, and so dispose of the anthropological speculation forever.

Still another highly suggestive specimen is No. 4, from Burma, a mixture of jadeite and analcite with a trace of diopside. Between jadeite, analcite, and the ferric equivalent of jadeite, acmite, there are relations of decidedly important character. The empirical formulæ of the three minerals are as follows: acmite, $NaFeSi_2O_6$; jadeite, $NaAlSi_2O_6$; analcite, $NaAlSi_2O_6H_2O$. That is, empirically analcite has the composition of jadeite plus one molecule of water. Fused jadeite has the properties of fused analcite, and in Norway pseudomorphs of analcite after acmite have been observed by Brögger. A relationship between the species is evident; but upon closer scrutiny it becomes more complex than it at first appears to be. Let us study the molecular volumes of the three minerals, the molecular volume being the quotient obtained upon dividing the molecular weight by the specific gravity.

	Molecular weight	Specific gravity	Molecular volume
Acmite, $NaFeSi_2O_6$ . .	231.8	3.50	66.2
Jadeite, $NaAlSi_2O_6$ . .	202.9	3.30	61.5
Analcite, $NaAlSi_2O_6H_2O$	221.0	2.25	98.2

Here we find acmite and jadeite near together, while analcite gives a volume one half greater. Between jadeite and analcite there is a difference in volume of 36.7 units, whereas the molecular volume of water alone, in the form of ice, is only 19.5. That is, a molecule of jadeite plus a molecule of ice would have a volume of only about 81 units, as against the 98.2 found. In short, a change from jadeite to analcite, if such a change occurred, would involve a very perceptible increase in volume over the sum of the two component parts, and this indicates that the simple molecular weights which we have taken are really submul-

tiples of the true values. The jadeite and acmite molecules are polymers of the anhydrous analcite molecule, and the alteration of one mineral into the other, as in the change from pyroxene to amphibole, means a breaking down from a higher molecular weight into a lower, and the same breaking down occurs when jadeite is fused. Jadeite itself is hardly, if at all, attacked by aqueous hydrochloric acid; but after fusion that reagent decomposes it readily. Analcite, whether natural or fused, is also easily decomposed by hydrochloric acid; and Lemberg has shown that the two minerals after fusion have become identical. This conclusion, together with that derived from a comparative study of the pyroxenes and amphiboles, bears directly upon the investigation of their chemical structure.

Now, leaving out of account all pseudo-jades, such as pectolite, fibrolite, or saussurite, and also neglecting all mixtures of minerals other than pyroxenes or amphiboles with jadeite or nephrite, let us consider the chemical formulæ of both species.

The simplest empirical formulæ are: *Pyroxenes*—Jadeite, $NaAlSi_2O_6$; acmite, $NaFeSi_2O_6$; diopside, $CaMgSi_2O_6$. Acmite and diopside are both identified by Penfield as isomorphously commingled with the normal jadeite. *Amphiboles*—Tremolite, $CaMg_3Si_2O_6$; actinolite, $Ca(MgFe)_3Si_2O_6$; glaucophane, $NaAl(FeMg)Si_3O_9$; riebeckite, $Na_2Fe'''_2Fe''Si_5O_{15}$. Normal nephrite approximates to tremolite or actinolite; but the glaucophane and riebeckite both appear in Penfield's discussion of certain analyses.

In all of the foregoing molecules the ratio of silicon to oxygen is 1 : 3, the ratio of a metasilicate. But a full discussion of the jadeite analyses shows that this ratio is sometimes exceeded, and to an extent which cannot be accounted for by the natural errors of experiment. This excess probably indicates the presence of a molecule represented by the generalized formula Al_2MgSiO_6; a compound which is not known in the free state, but which is well recognized in all the best theoretical interpretations of the amphiboles and pyroxenes. In jade it is small in amount, and for most purposes it may be neglected; but in augite, one of the most important pyroxenes, its presence seems to be very evident. In this connection it is mentioned simply as one link in a chain of evidence as to the nature of the substances under consideration.

It has already been shown that the pyroxene molecules are more condensed than those of the amphibole group; and this may be more clearly brought out by a further study of the molecular volumes. Taking the empirical formulæ as indicating for each mineral the minimum possible molecular weight, let us make the comparison here suggested.

	Molecular weight	Specific gravity	Molecular volume	Mean volume
Jadeite, $NaAlSi_2O_6$	202.9	3.30	61.5	61.5
Acmite, $NaFeSi_2O_6$	231.8	3.50	66.2	66.2
Diopside, $CaMgSi_2O_6$	217.1	3.20	67.8	67.8

The three pyroxenes run pretty well together; part of the difference being due to the fact that the ideally pure molecules were not used for the specific gravity determinations. Now let us pass on to the amphiboles.

	Molecular weight	Specific gravity	Molecular volume	Mean volume
Tremolite, $CaMg_3Si_2O_6$	418.5	2.94	142.4	71.2
Glaucophane,[1] $NaAl(FeMg)Si_3O_9$.	314.2	3.10	101.4	67.6
Riebeckite, $Na_2Fe'''_2Fe''Si_5O_{15}$ . .	596.0	3.40	175.3	70.1

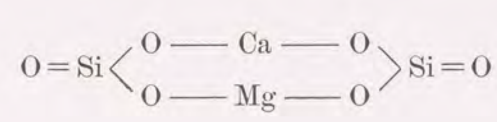
The last column gives the volume proportional to Si_2O_6; a factor which occurs once in the pyroxenes, twice in tremolite, one and a half times in glaucophane, and two and a half times in the empirical riebeckite formula. This column reduces all the minerals to a common denominator, and renders a comparison possible. From it we see that the pyroxenes and amphiboles are near each other in molecular volume, but that the amphiboles tend to run perceptibly higher. In other words, the amphibole molecules are less con-

[1] Computed with Mg : Fe : : 2 : 1.

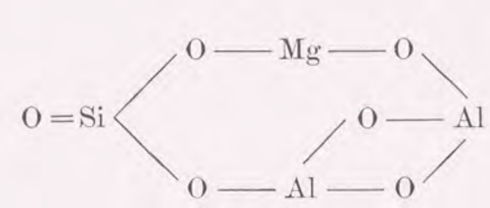
densed, and therefore occupy more volume, than the molecules of pyroxene. Or, to state the result in still another form, the pyroxenes, atom for atom, represent the larger weight of matter in the unit volume of space. The true molecular weights are multiples of the empirical values, and those of the pyroxenes are the greater.

This view as to the molecular magnitudes under consideration is diametrically opposed to the most commonly accepted opinions. The latter take the simplest empirical formulæ alone; and as many amphiboles are representable only by relatively high expressions, these are regarded as indicating greater molecular weights. The supposed simplicity of the pyroxenes, however, is apparent rather than real, and disappears when all of the evidence is considered in all of its bearings. A mineral cannot be properly studied by itself alone; it must be interpreted with relation to other species, from some of which it may be derived, or into which it may alter. These relations must be expressed in its formula before the latter can be regarded as fully established. An empirical formula represents composition only; a structural formula takes into account molecular weight and relationship to other compounds also. The one is simple, the other may be complex; but that is best which best fulfils its purpose and symbolizes the largest number of facts. Among the various formulæ which have been proposed for pyroxenes and amphiboles, what system best satisfies all the conditions? That is the problem now to be considered.

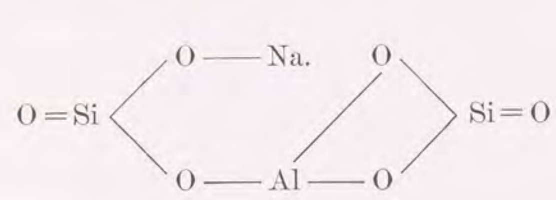
According to the current and more commonly accepted opinions, both groups of minerals are salts of metasilicic acid, and the simple empirical formulæ are merely restated in structural form. On this basis diopside becomes



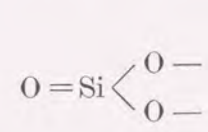
and the molecule Al_2MgSiO_6 is written



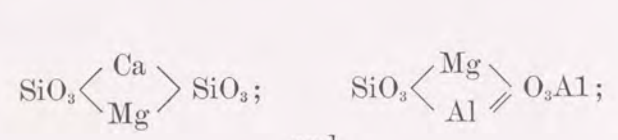
These expressions indicate a simple relationship in form, and by comminglings of the two types a large number of pyroxenes are expressible. On a similar plan, jadeite may be given the structure



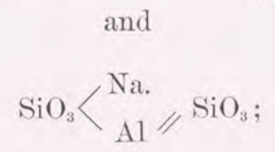
and here again the superficial resemblance is apparent. For convenience these formulæ can be put in more condensed form, the metasilicate group



being written SiO_3, and then the expressions become

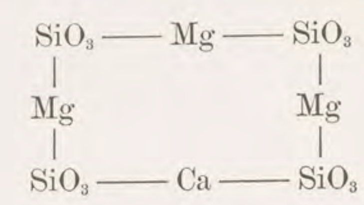


and

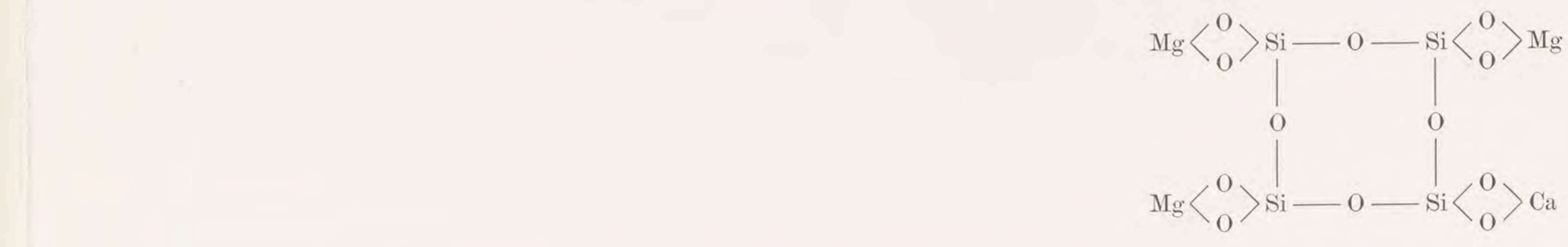


a plan which is easier for the eye and which avoids repetition of symbols.

On similar lines, tremolite may be written also as a metasilicate



or as a salt of the more complex acid $H_8Si_4O_{12}$. In the latter case its structure is indicated thus:



the eight hydrogen atoms of the acid being replaced by the four bivalent atoms of magnesium and calcium. These expressions for tremolite are well enough so far as they go; but the other amphiboles, such as glaucophane and riebeckite, are difficult to adjust with them. Partial evidence may well be easier to interpret than complete evidence.

Going beyond the empirical formulæ as a basis for study, a clue to the condition of jadeite is found in the properties of another pyroxene, the mineral spodumene. This species, with jadeite and acmite, forms a well-defined series of compounds, whose empirical formulæ are as follows:

Spodumene,	$LiAlSi_2O_6$
Jadeite,	$NaAlSi_2O_6$
Acmite,	$NaFeSi_2O_6$

Spodumene, then, resembles jadeite, except that it contains lithium instead of sodium. In form and density the species are closely allied, and the evidence obtained by the study of one probably applies to all three. The molecular magnitudes should be strictly similar.

It so happens that the alteration products of spodumene have been very thoroughly studied; and their investigation has shed much light upon the character of the mineral. It takes up soda quite easily, probably from percolating waters, and becomes transformed into a mixture of albite and eucryptite, which may be compared with the original spodumene thus:

Spodumene,	Sp. Gr. 3.15	$LiAlSi_2O_6$
Eucryptite,	" " 2.67	$LiAlSiO_4$
Albite,	" " 2.62	$NaAlSi_3O_8$

Both eucryptite and albite are much lower in density than spodumene, and their molecular complexity should therefore, in all probability, be less. In order to effect this change, the molecular weight must be at least double that indicated by the empirical formula, and then it becomes $Li_2Al_2Si_4O_{12}$ or possibly greater. This expression is a minimum. Eucryptite in turn alters into muscovite mica, of which the simplest formula is $Al_3KH_2Si_3O_{12}$, and to satisfy this condition the eucryptite formula must be trebled. This consideration, taken in connection with the albite and the spodumene, goes to show that the latter mineral must be given a formula six times greater than the original expression, and so it becomes $Li_6Al_6Si_{12}O_{36}$. The formulæ for jadeite and acmite must be treated in the same way, and the final result for jadeite is $Na_6Al_6Si_{12}O_{36}$.

Does this represent a metasilicate, or is the metasilicate ratio $Si : O_3$ only apparent? Just as spodumene alters into albite and eucryptite, so jadeite should alter into albite and nepheline $(NaAlSiO_4)_3$; and the splitting up would be according to the equation

$$\underset{\textit{Jadeite}}{Na_6Al_6Si_{12}O_{36}} = \underset{\textit{Albite}}{Na_3Al_3Si_9O_{24}} + \underset{\textit{Nepheline}}{NaAl_3Si_3O_{12}}$$

Albite is a derivative of trisilicic acid, $H_4Si_3O_8$; and nepheline is a salt of orthosilicic acid, H_4SiO_4. When orthosilicates and trisilicates are commingled, ratios like those of the metasilicates are produced; for $H_4SiO_4 + H_4Si_3O_8 = H_8Si_4O_{12}$, and the latter as a mixture would exactly represent four molecules of metasilicic acid, H_2SiO_3. Such mixtures are common among minerals, especially in the feldspar, scapolite, and

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No. 362

PLUM-TREE VASE

(*Mei Hua P'ing*)

Ming Dynasty (1368–1644)

Jadeite

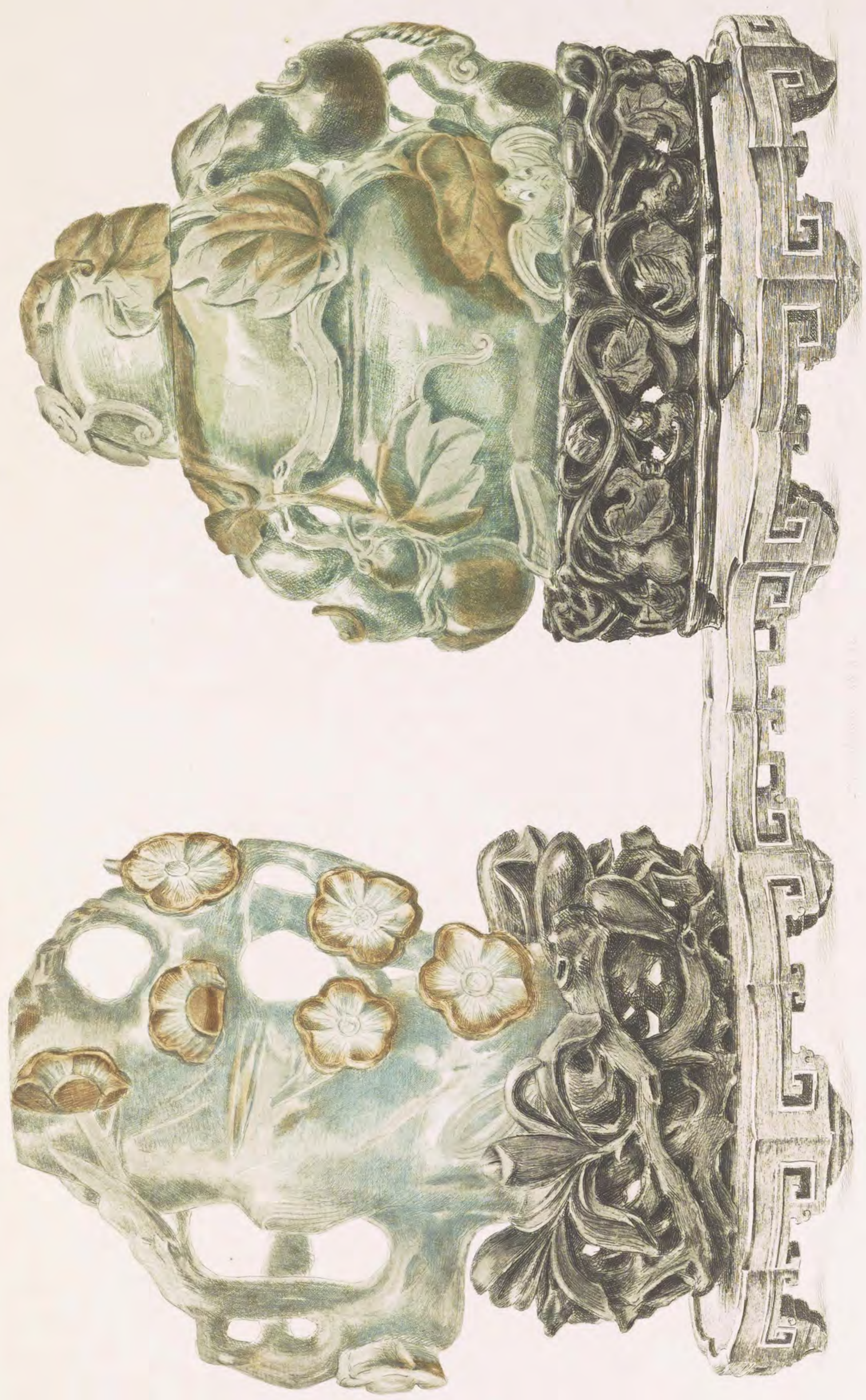
No. 363

GOURD-SHAPED VASE

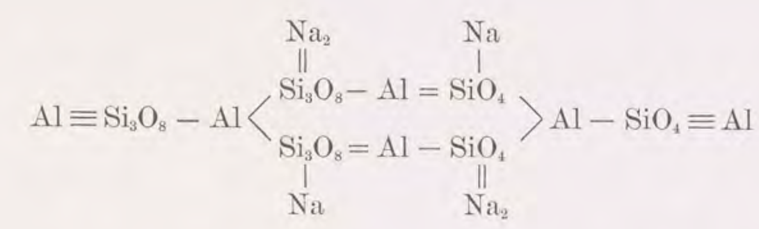
(*Hu Lu P'ing*)

Ming Dynasty (1368–1644)

Jadeite

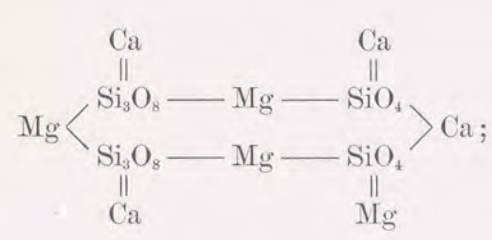


mica groups; and the possibility of a similar occurrence must be considered here. The radicals SiO_4 and Si_3O_8 seem to be equivalent to each other; and on this supposition the formula $Na_6Al_6Si_{12}O_{36}$ may be written structurally,

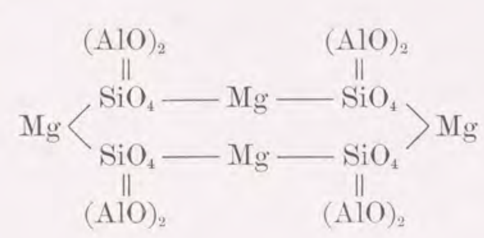


Such a molecule as this could split directly into the two molecules $Al_3Na_3(Si_3O_8)_3$ (albite) and $Al_3Na_3(SiO_4)_3$ (nepheline); and it seems to satisfy all of the conditions imposed by the different phases of the problem.

The unification of the other pyroxene formulæ with this new formula for jadeite now becomes a very simple matter. Diopside, $MgCaSi_2O_6$, becomes $Mg_4Ca_4Si_8O_{24}$; and the hypothetical compound Al_2MgSiO_6 is also quadrupled. In diopside a mixed orthosilicate and trisilicate is assumed; and in the other compounds we have a basic orthosilicate containing the well-recognized univalent radical AlO. Two AlO groups are structurally equivalent to one atom of calcium or magnesium. We thus have, for diopside,

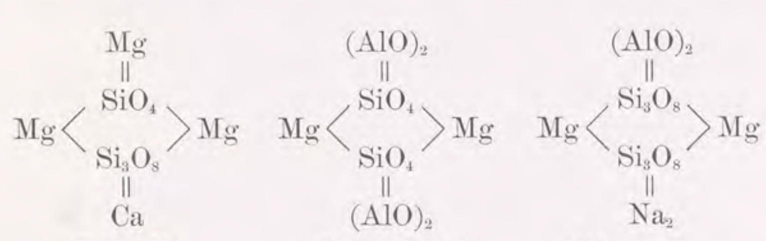


and for the other molecule the structure



All of the other pyroxenes are capable of similar interpretations; and thus the entire group is reduced to one general type of constitution. No other mode of interpretation hitherto proposed is equally general.

For the amphiboles a similar treatment is possible; and they too can be regarded as mixed orthosilicates and trisilicates, the metasilicate ratios being apparent only. Nephrite, it will be remembered, approximates to tremolite and actinolite, but its molecule is less complex than that of jadeite, and is formed by a lower degree of condensation. In the amphiboles we also find admixtures of a compound Al_2MgSiO_6, which is not known by itself; and this, as in the case of the pyroxene, is covered by the following scheme:



Tremolite $(MgAl_2SiO_6)_2$ *Glaucophane*

Riebeckite and crocidolite are possibly the equivalents of glaucophane, with ferric iron replacing aluminium, and ferrous iron in place of magnesium. But their analyses vary too widely to admit of any final conclusion upon this point. The empirical formula used for riebeckite in the preceding pages is merely the formula which is commonly assumed, but which does not fit the analytical data at all closely.

To sum up: the formulæ here developed represent the known relations between the pyroxenes and the amphiboles in general, and between jadeite and nephrite in particular. They cover the evidence so far as evidence exists; but they may not be final. A formula is merely a symbol for expressing facts; and new facts may compel the abandonment of one symbol for another of broader scope. Written in structural form, they bring evidence more clearly before the eye, and they suggest investigations through which more truth may become attainable. That function—the function of suggestiveness—is one of their chief values.

THE CHEMICAL ANALYSES

For the purposes of the investigation begun by Mr. Bishop some fourscore chemical analyses were made from typical specimens in his Collection. This analytic work was carried out by Mr. Percy T. Walden, and later by Dr. Harry W. Foote, both of the Sheffield Scientific School at Yale University, under the direct supervision of Mr. S. L. Penfield, Professor of Mineralogy at Yale. Of the total number of analyses several were merely qualitative, and others quantitative for the alkali metals only, and these are not here recorded. The others are given below in tabular form, and are discussed in the paper by Professor Penfield which follows. This is followed by detailed descriptions of the several specimens analyzed, with reductions and notes by Clarke and Penfield. The jadeites, in the order of their purity, come first, and then the nephrites, similarly arranged. The table includes two specimens by other hands—namely, No. 134*a* by Dr. Steiger of the United States Geological Survey, Washington, D. C., and No. 134*b* by Dr. Karl Busz, of Münster, Westphalia, Germany.

The method of analysis used by Walden and Foote was that almost universally adopted for silicate analyses of this character.

Water was determined by igniting about one gramme of the air-dry material over a blast-lamp. The residue from the water determination was fused with sodium carbonate, extracted with water, acidified with hydrochloric acid, evaporated to dryness, and the silica filtered off. The filtrate was again evaporated to remove the last trace of silica, which was added to the first, and the whole ignited to constant weight, and silica determined by loss on evaporation with hydrofluoric acid.

Iron and alumina were precipitated in the filtrate from the silica, and the precipitate was dissolved in nitric acid, reprecipitated to ensure purity, and ignited to constant weight over a blast-lamp. The residue of Fe_2O_3 and Al_2O_3 was dissolved by means of a potassium bisulphate fusion, the fusion being soaked out in water containing sulphuric acid. If a trace of silica were found at this point, it was added to the silica previously obtained. The total iron was then found by reducing the hot sulphate solution with hydrogen sulphide and titrating with potassium permanganate.

The two filtrates from the iron and alumina precipitation were concentrated and calcium was precipitated as oxalate. When more than a very few per centum was present it was dissolved and reprecipitated, being weighed as oxide.

In the filtrate, magnesia was precipitated as ammonium magnesium phosphate, and the first precipitate was always dissolved and reprecipitated to ensure purity. It was weighed as $Mg_2P_2O_7$.

Ferrous iron was determined by titration with potassium permanganate, after solution of the mineral in hydrofluoric acid in an atmosphere of Co_2.

Alkalis were determined by a Smith fusion with calcium carbonate and ammonium chloride, being separated from each other by platinum solution.

TABULAR STATEMENT OF ANALYSES OF SPECIMENS IN THE COLLECTION

	No.	Silica SiO_2	Titanic oxide TiO_2	Phosphoric oxide P_2O_5	Alumina Al_2O_3	Chromic oxide Cr_2O_3	Ferric oxide Fe_2O_3	Ferrous oxide FeO	Manganese oxide MnO	Nickel oxide NiO	Magnesia MgO	Lime CaO	Soda Na_2O	Potassa K_2O	Water H_2O	TOTAL
I	41	57.60			25.75				trace		.13	.58	13.31	2.20	.25	99.82
II	32	58.86			25.12		.16	.12	trace		.27	.44	14.62	.08	.19	99.86
III	51	58.80			25.37		.33				.25	.58	14.65	.05	.14	100.17
IV	42	58.69			25.56				trace		.11	.58	13.09	1.54	.17	99.74
V	362	58.93	.15		25.39				trace		.29	.72	12.90	1.63	.23	100.24
VI	7	58.58			23.71		.51	.24			1.35	1.67	13.80	trace	.30	100.16
VII	16	57.45			21.94		.91		trace		3.96	3.10	12.13		.79	100.28
VIII	16	57.79			21.40		.80		trace		4.72	3.06	12.36		.76	100.89
IX	16	57.49			21.56		1.05		trace		4.79	2.90	11.98		.45	100.22
X	490	58.40			27.05				trace		.57	.65	11.37	2.20	.18	100.42

TABULAR STATEMENT OF ANALYSES OF SPECIMENS IN THE COLLECTION (*Continued*)

	No.	Silica SiO_2	Titanic oxide TiO_2	Phosphoric oxide P_2O_5	Alumina Al_2O_3	Chromic oxide Cr_2O_3	Ferric oxide Fe_2O_3	Ferrous oxide FeO	Manganese oxide MnO	Nickel oxide NiO	Magnesia MgO	Lime CaO	Soda Na_2O	Potassa K_2O	Water H_2O	TOTAL
XI	496	58.48			23.57		1.68		trace		1.33	1.62	10.33	3.09	.16	100.26
XII	485	59.02			24.88		1.23	.28	.19		1.10	1.15	11.21	1.34	.07	100.47
XIII	219	56.69			20.46		4.49	.75	trace		1.64	3.28	11.65	1.15	.48	100.59
XIV	177	56.08			19.05		3.76	2.26			2.08	4.94	11.61	.26	.18	100.22
XV	4	58.41			24.64		.67				1.24	1.43	12.76	.58	1.19	100.92
XVI	18	57.36			14.01		1.37	.79			11.07	1.91	11.32	.53	1.55	99.91
XVII	303	63.47			20.76		1.27		trace		11.11	1.16	11.98	.34	.36	100.45
XVIII	317	57.37			1.03		.78		trace		23.96	13.03	undet.	undet.	3.63	99.80
XIX	79	57.14			1.20		.12	.21	.04		25.67	12.65	.29	.08	2.54	99.94
XX	153	57.09			.53		.81	3.98			22.28	11.75	.21		3.57	100.22
XXI	78	56.43			.88	.15	.54	3.62	.07	.06	22.68	12.85	.15	.07	2.36	99.86
XXII	155	57.02			.70		1.04	4.33			21.56	12.63	.22		3.01	100.51
XXIII	234	56.70			2.01			5.09			21.91	12.12	.14		2.56	100.53
XXIV	330	57.02			1.05		1.10		trace		23.01	14.77	undet.	undet.	3.00	99.95
XXV	134*c*	56.74			.93	.13	.75	3.64	.06	.09	21.75	13.09	.22	trace	2.42	99.82
XXVI	83	57.38			.83		1.71	trace	trace		23.37	13.14	.33		3.51	100.27
XXVII	458	54.44			.82		.38	.34	trace		25.88	13.70	.70	.54	3.48	100.28
XXVIII	618	57.28			1.46		.56	1.19	.28		20.88	13.15	2.61	1.23	1.79	100.43
XXIX	134*a*	56.39	trace	trace	1.63		1.72	3.70	.26	.13	24.63	7.92			4.07	100.45
XXX	180	55.48			.89		.90	3.47	trace		22.69	12.89	.80	.44	3.12	100.68
XXXI	67	55.93			1.64		.12	.29	.16		26.05	11.59	.40	.19	3.43	99.80
XXXII	81	57.77			2.50		2.76		trace		20.91	13.61	trace	trace	3.52	101.07
XXXIII	183	58.66			.50		1.76	3.48	.02		22.43		.48	.10	.12	100.89
XXXIV	765	55.51			1.72		1.33	7.69			18.80	13.17	.41		1.82	100.45
XXXV	160	58.14			.98		3.39	.85	.22		22.38	12.53	.36		1.69	100.54
XXXVI	97	58.59			2.33		.97	.11	.35		22.30	12.41	.98	.21	1.54	99.79
XXXVII	581	56.66			2.74		.56	.51	trace		23.42	12.52	1.16		2.23	99.80
XXXVIII	80	57.82			1.14		4.10		trace		20.49	13.93	.31		3.08	100.87
XXXIX	443	57.89			1.99		1.36		trace		20.74	12.60	2.06		3.38	100.02
XL	182	57.19			2.24		1.60	1.10	trace		21.97	13.16	.20	1.44	1.82	100.72
XLI	449	57.46			2.70		.83		trace		20.87	12.49	1.79	1.64	2.71	100.49
XLII	120	55.96			2.33		4.28		trace		20.35	13.49	.51	trace	2.72	99.64
XLIII	648	57.42			2.66		1.31	1.78	.28		14.30	16.19	1.93		3.69	99.56
XLIV	162	57.78			2.35		1.60	2.83			14.80	15.02	1.63	1.00	2.75	99.76
XLV	299	56.41			.91		3.84	1.92	.15		19.09	12.81	2.64		2.56	100.53
XLVI	159	56.63			2.14		3.99				21.69	13.41	.20	.69	1.67	100.42
XLVII	351	56.91			2.84		1.56		trace		21.82	11.56	1.62	1.19	3.07	100.57
XLVIII	104	57.65			1.06		4.93	.11			14.95	16.05	2.38	.93	2.46	100.52
XLIX	96	57.43			3.14		1.88	.47	trace		19.68	12.04	2.87		2.61	100.12
L	630	56.83			5.33		.46		trace		19.38	13.11	2.25		3.44	100.80
LI	134*b*	52.58	.12		6.74		2.76	1.72	trace		21.02	9.84	.54	.28	4.79	100.39
LII	71	58.04			2.23		4.64	.16	.38		14.50	12.68	4.83	.39	2.83	100.68
LIII	99	56.13			5.06		2.12	1.01	trace		19.20	11.88	1.19	1.90	2.29	100.78
LIV	289	52.60			1.45		2.10	2.14	.10		23.06	12.72	.93	.57	3.62	99.29
LV	322	52.08			1.79		.05	.46	.05		25.49	13.39	1.11	.71	3.50	99.53
LVI	130	49.55			5.20	.24	.78	4.44	.07	.18	24.78	9.54	.15	.05	4.68	99.66
LVII	141	54.44			5.92		3.72	2.56	.22		16.79	7.51	4.64	.28	4.12	100.20
LVIII	172	51.33			18.31		8.08				4.05	11.34	5.76	.55	.76	100.18

DISCUSSION OF THE ANALYSES

Jadeite

IN its chemical nature jadeite is a silicate of sodium and aluminium, and the formula assigned to it is $NaAl(SiO_3)_2$. The theoretical composition of the ideally pure mineral is as follows:

Silica,	SiO_2,	59.40%
Alumina,	Al_2O_3,	25.25
Soda,	Na_2O,	15.35
		100.00

An examination of the jadeite analyses given above indicates that although silica, alumina, and soda are the essential constituents, small amounts of other substances are always present. The silica maintains a fairly uniform percentage, close to that demanded by the theory. The same is true of the alumina, although

it falls below the theory when ferric oxide, Fe_2O_3, is present. This latter oxide plays the same rôle in chemical compounds as alumina, and has, therefore, the property of replacing alumina in complex mineral substances. Or it may be considered that the jadeite molecule $NaAl(SiO_3)_2$ is replaced in part by the isomorphous ægirite molecule $NaFe(SiO_3)_2$. When the percentages of soda are considered it will be observed that the amounts fall considerably below the theory. These deficiencies are largely made up by potash, K_2O, which may replace soda, since it is similar to it in its chemical relations, but still there is a deficiency of the combined alkalis, soda plus potash. The rôle played by the small amounts of lime, CaO, and magnesia, MgO, is somewhat questionable. Together they combine with silica to form a variety of pyroxene known as diopside, $CaMg(SiO_3)_2$, and the presence of varying amounts of this silicate with jadeite might be expected. The analyses, however, indicate that the diopside molecule usually is not present, for it contains no alumina, and its presence with jadeite would be indicated by a lowering of the percentage of alumina. In some complex silicates lime, CaO, and magnesia, MgO, play the same rôle as the alkalis Na_2O and K_2O, and it would seem from the analyses of jadeite in the Collection that the small amounts of these oxides act like the potash in replacing soda. The traces of ferrous oxide, FeO, and loss on ignition (probably water) may be disregarded in considering the composition of jadeite.

In order to show that ferric oxide replaces alumina, and that potash, lime, and magnesia replace soda, the analyses have been modified by substituting for Fe_2O_3 an amount of Al_2O_3 equivalent to it, and for K_2O, CaO, and MgO their equivalent of Na_2O, and then calculating to one hundred per centum. The recalculated analyses can thus be compared with the theoretical composition of jadeite, and it will be observed that the agreement is very satisfactory:

	I	II	III	IV	V
Number	496	485	490	41	42
Specific gravity . . .	3.3394	3.3381	3.3373	3.3303	3.3287
Silica, SiO_2	58.48	59.02	58.40	57.60	58.69
Alumina, Al_2O_3 . . .	23.57	24.88	27.05	25.75	25.56
Ferric oxide, Fe_2O_3 . .	1.68	1.23			
Magnesia, MgO . . .	1.33	1.10	.57	.13	.11
Lime, CaO	1.62	1.15	.65	.58	.58
Soda, Na_2O	10.33	11.21	11.37	13.31	13.09
Potash, K_2O	3.09	1.34	2.20	2.20	1.54
Ferrous oxide, FeO . .		.28			
Manganous oxide, MnO.		.19			
Loss on ignition, H_2O .	.16	.07	.18	.25	.17
	100.26	100.47	100.42	99.82	99.74

The analyses, after making the substitutions and recalculating to one hundred per centum, are as follows:

	I	II	III	IV	V	Theory for jadeite $NaAl(SiO_3)_2$
Silica, SiO_2 . . .	58.48	59.02	58.40	57.60	58.69	
Alumina, Al_2O_3 .	24.59	25.59	27.05	25.75	25.56	
Soda, Na_2O . . .	16.22	15.01	14.34	15.54	14.88	
	99.29	99.62	99.79	98.89	99.13	
Silica, SiO_2 . . .	58.90	59.25	58.52	58.25	59.20	59.40
Alumina, Al_2O_3 .	24.77	25.69	27.12	26.04	25.79	25.25
Soda, Na_2O . . .	16.33	15.07	14.36	15.71	15.01	15.35
	100.00	100.00	100.00	100.00	100.00	100.00

It may thus be concluded that potash, K_2O, and small amounts of lime, CaO, and magnesia, MgO, may replace soda in jadeite.

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No. 491

SCEPTRE

(*Ju-i*)

Ch'ien-lung (1736–95)

Jadeite

Mixture of Jadeite with other Materials

The analyses indicate that there are in the Collection a few specimens which are mixtures of jadeite with other minerals. Some of these are isomorphous mixtures of the different members of the pyroxene group, jadeite, ægirite, and diopside; and in one sense these are not mixtures, since the different molecules can combine together into a homogeneous crystal. In other cases the material is an intergrowth of different minerals.

Pyroxene—Essentially Jadeite

Number 219. The existence of a rather large amount of ferric oxide indicates the presence of the ægirite molecule $NaFe(SiO_3)_2$ and accounts undoubtedly for the dark color of the material. Also the somewhat low percentages of combined alumina and ferric oxide, together with the considerable amounts of lime and magnesia, indicate the presence of the diopside molecule $CaMg(SiO_3)_2$.[1] The analysis shows that the material is a pyroxene, essentially jadeite, and that the molecules are present in the proportion indicated below:

		Diopside $Ca(MgFe)(SiO_3)_2$	Ægirite $NaFe(SiO_3)_2$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Specific gravity . .	3.3034					
Silica, SiO_2	56.69	4.98	6.72	44.99	57.85	59.40
Alumina, Al_2O_3 . .	20.46			20.46	26.31	25.25
Ferric oxide, Fe_2O_3 .	4.49		4.49			
Ferrous oxide, FeO .	.75	.75				
Magnesia, MgO . .	1.64	1.28		.36		
Lime, CaO	3.28	2.29		.99		
Soda, Na_2O	11.65		1.74	9.91	15.84	15.35
Potash, K_2O . . .	1.15			1.15		
Loss on ignition, H_2O	.48					
	100.59	9.30	12.95	77.86	100.00	100.00

Number 16. Three analyses indicate that there is no essential difference between the green and the lavender portions. The slight excess of ferric oxide in the green portion indicates the presence of a little more of the ægirite molecule. The somewhat low percentage of alumina and the high percentage of lime and magnesia indicate the presence of the diopside molecule. The calculation has been made upon the analysis of the mixture, and shows that the material is pyroxene, with the jadeite molecule predominating.

	Lavender	Green	Mixture	Diopside $CaMg(SiO_3)_2$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Specific gravity . .			3.2578				
Silica, SiO_2	57.79	57.49	57.45	7.80	49.65	57.88	59.40
Alumina, Al_2O_3 . .	21.40	21.56	21.94		21.94	26.24	25.25
Ferric oxide, Fe_2O_3 .	.80	1.05	.91		.91		
Magnesia, MgO . .	4.72	4.79	3.96	3.00	.96		
Lime, CaO	3.06	2.90	3.10	3.10			
Soda, Na_2O	12.36	11.98	12.13		12.13	15.88	15.35
Potash, K_2O . . .							
Loss on ignition, H_2O	.76	.45	.79				
	100.89	100.22	100.28	13.90	85.59	100.00	100.00

The water in this material and the one previous may indicate the presence of a small amount of analcite, $NaAl(SiO_3)_2+H_2O$. Analcite and diopside would tend to bring the specific gravity below that of normal jadeite, while ægirite, specific gravity 3.5, would tend to increase it.

[1] A little iron replaces the magnesia.

Jadeite and Analcite

Number 4. The low specific gravity of this material is noticeable. The analysis is like that of a jadeite, except for the quantity of water. Professor Iddings, in his examination of thin sections of it, has noted the presence of an isotropic substance with the properties of analcite, $NaAl(SiO_3)_2 + H_2O$, and the presence of this mineral would account both for the low specific gravity of the material and the water. The specific gravity of analcite is 2.28.

		Diopside $CaMg(SiO_3)_2$	Analcite $NaAl(SiO_3)_2+H_2O$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Specific gravity . . .	3.2176					
Silica, SiO_2	58.41	1.50	15.84	41.07	58.37	59.40
Alumina, Al_2O_3	24.64		6.73	17.91	26.05	25.25
Ferric oxide, Fe_2O_3 . .	.67			.67		
Magnesia, MgO . . .	1.24	.52		.72		
Lime, CaO	1.43	.67		.76		
Soda, Na_2O	12.76		4.09	8.67	15.58	15.35
Potash, K_2O	.58			.58		
Loss on ignition, H_2O .	1.19		1.19			
	100.92	2.69	27.85	70.38	100.00	100.00

In this connection it is interesting to note the similarity in chemical composition between jadeite, $NaAl(SiO_3)_2$, and analcite, $NaAl(SiO_3)_2 + H_2O$. J. Lemberg[1] has shown, moreover, that although jadeite is only slightly acted upon by acids and alkaline solutions, fused jadeite can readily be converted into analcite by subjecting it to the action of a hot dilute solution of sodium carbonate under pressure.

Glaucophane and Zoisite (Clinozoisite?)

Number 172. Only one example of this mixture has been observed in the Collection. Under the microscope there were observed epidote of pale color and low double refraction corresponding to clinozoisite ("Zeitschr. Kryst.," Vol. XXVI, page 166), a little quartz, and abundant material having the cleavage and optical properties of a mineral belonging to the amphibole group. The presence of nearly six per centum of soda in the specimen indicates that the amphibole mineral must be related to glaucophane and riebeckite, which are believed to contain respectively the molecules $NaAl(SiO_3)_2$ and $NaFe(SiO_3)_2$, similar to the soda-alumina and soda-iron silicates jadeite and ægirite. The amounts of alumina, ferric oxide, and alkalis furnish a basis for calculating the chemical composition as follows:

		Glaucophane			Epidote	Quartz
		$NaAl(SiO_3)_2$	$NaFe(SiO_3)_2$	$(MgCa)SiO_3$	$HCa_2Al_3Si_3O_{13}$	SiO_2
Specific gravity . .	3.0919					
Silica, SiO_2	51.33	11.76	12.00	7.92	15.48	4.17
Alumina, Al_2O_3 . .	18.31	5.00			13.31	
Ferric oxide, Fe_2O_3 .	8.08		8.08			
Magnesia, MgO . .	4.05			4.05		
Lime, CaO	11.34			1.71	9.63	
Soda, Na_2O	5.76	2.66	3.10			
Potash, K_2O . . .	.55	.55				
Water, H_2O . . .	.76				.76	
	100.18	19.97	23.18	13.68	39.18	4.17

[1] Zeitschrift der Deutschen Geologischen Gesellschaft, 1887, Vol. XXIX, p. 587.

The glaucophane molecules combined constitute 56.83 per centum of the total material, and are given below after calculation to one hundred per centum. There are also given for comparison two analyses of glaucophane from Lyra, one of the Cyclades—the first by Schnedermann and the second by Luedecke (Analyses 1 and 2, page 399, Dana's "System of Mineralogy").

No. 172

	Calculation	Glaucophane from Lyra	
		I	II
Silica, SiO_2	55.74	56.49	55.64
Alumina, Al_2O_3 . . .	8.80	12.23	15.11
Ferric oxide, Fe_2O_3 . .	14.22		3.08
Ferrous oxide, FeO . .		10.91	6.85
Manganese oxide, MnO		.50	.56
Magnesia, MgO . . .	7.13	7.80	7.80
Lime, CaO	3.01	2.40	2.40
Soda, Na_2O	10.13	9.34	9.34
Potash, K_2O	.97		
	100.00	99.67	100.78

In most respects No. 172 compares favorably with the glaucophane analyses given for comparison, the discrepancies being in the alumina and oxides of iron. It must be borne in mind, however, that in the calculation all of the iron oxide has been credited to the glaucophane, while undoubtedly part of it belongs to the epidote. It is safe, therefore, to assume that the glaucophane contains somewhat more alumina and less ferric oxide than indicated by the foregoing calculation, but the amount could not be determined without analysis of either the epidote or the glaucophane.

Jadeite and Albite

Among the minerals analyzed there is only one example of this kind of mixture—

No. 303

		Nephrite $CaMg(SiO_3)_4$	Jadeite $NaAl(SiO_3)_2$	Albite $NaAlSi_3O_8$	Theoretical comparison of a mixture of		
					Nephrite	Jadeite	Albite
Specific gravity . . .	2.8345						
Silica, SiO_2	63.47	2.20	28.80	32.47	2.17	28.87	32.48
Alumina, Al_2O_3 . . .	20.76		11.53	9.23		12.43	9.20
Ferric oxide, Fe_2O_3 . .	1.27		1.27				
Magnesia, MgO . . .	1.11	1.11			1.08		
Lime, CaO	1.16	.50	.66		.50		
Soda, Na_2O	11.98		6.63	5.35		7.46	5.81
Potash, K_2O	.34			.34			
Water, H_2O	.36						
	100.45	3.81	48.89	47.39	3.75	48.76	47.49

The analysis indicates the presence of a little nephrite.

Nephrite

Our knowledge of the chemical composition of the amphiboles is not as satisfactory as that of the pyroxenes. The formula $CaMg_3(SiO_3)_4$ is assigned to a white variety of amphibole known as tremolite, while ferrous iron replaces a part of the magnesia in the green varieties. Small amounts of alumina, ferric oxide, the alkalis soda and potash, and water occur in the amphiboles, but just how they are combined in the chemical molecule is not in all cases well understood. The theoretical percentage composition corresponding to the formula of tremolite, $CaMg_3(SiO_3)_4$, is given as follows, in the annexed table:

Silica, SiO_2,	57.69
Magnesia, MgO,	28.85
Lime, CaO,	13.46
	100.00

On examining the analyses of nephrite it will be observed that the percentages of silica, SiO_2, and lime, CaO, maintain nearly uniform values near those demanded by the theory of tremolite, but the magnesia, MgO, percentages exhibit not only a considerable variation, but they are lower than the theory. The deficiencies in magnesia are probably in part accounted for by the presence of water, since it has been shown by the analyses of a very pure variety of anthophyllite,[1] a mineral closely related to tremolite, that water can replace magnesia. It is not probable that the water shown by the analyses comes from serpentine, since the presence of the latter mineral would very perceptibly lower both the specific gravity and the percentage of silica.

The small quantities of alumina and ferric oxide are usually accompanied by an amount of soda sufficient to form the molecules $Na_2Al_2(SiO_3)_4$ and $Na_3Fe_3(SiO_3)_4$. These molecules are present respectively in the minerals glaucophane and riebeckite, which belong to the amphibole group, and they are analogous in composition to jadeite and ægirite of the pyroxene group. Potash may take the place of soda in these molecules.

The analyses of nephrite show a great similarity, and the calculation of a few of them will serve to illustrate the prevailing composition. As a basis of calculation the alumina and ferric oxide have been combined with sufficient silica and alkalis to form the glaucophane and riebeckite molecules. The remaining silica has then been combined with ferrous oxide, magnesia, lime, and water to form a silicate, nephrite, of the general formula $RSiO_3$ (R=Fe, Mg, Ca, and H_2). For the sake of comparison with the tremolite formula, $CaMg_3(SiO_3)_4$, the nephrite has been recalculated to one hundred per centum after increasing the magnesia by an amount equivalent to that of the ferrous oxide and water.

No. 104

		Glaucophane $Na_2Al_2(SiO_3)_4$	Riebeckite $Na_2Fe_2(SiO_3)_4$	Nephrite $RSiO_3$	Nephrite calculated to 100%	Theory
Specific gravity .	3.0138					
Silica, SiO_2 . . .	57.65	2.40	7.44	47.81	56.76	57.69
Alumina, Al_2O_3. .	1.06	1.06				
Ferric oxide, Fe_2O_3	4.93		4.93			
Ferrous oxide, FeO	.11			.11		
Magnesia, MgO .	14.95			14.95	24.19	28.85
Lime, CaO . . .	16.05			16.05	19.05	13.46
Soda, Na_2O . . .	2.38	.62	1.76			
Potash, K_2O . .	.93		.28			
Water, H_2O . . .	2.46			2.42		
	100.52	4.08	14.41	81.34	100.00	100.00
Unaccounted for: Potash 0.65; water 0.04=0.69						

The presence of a rather large amount of the riebeckite molecule in this nephrite is noticeable.

No. 162

		Glaucophane $Na_2Al_2(SiO_3)_4$	Riebeckite $Na_2Fe_2(SiO_3)_4$	Nephrite $RSiO_3$	Nephrite calculated to 100%	Theory
Specific gravity .	3.0122					
Silica, SiO_2 . . .	57.78	5.52	2.40	49.86	57.52	57.69
Alumina, Al_2O_3. .	2.35	2.35				
Ferric oxide, Fe_2O_3	1.60		1.60			
Ferrous oxide, FeO	2.83			2.83		
Magnesia, MgO .	14.80			14.80	25.15	28.85
Lime, CaO . . .	15.02			15.02	17.33	13.46
Soda, Na_2O . . .	1.63	1.01	0.62			
Potash, K_2O . .	1.00	.66				
Water, H_2O . . .	2.75			2.45		
	99.76	9.54	4.62	84.96	100.00	100.00
Unaccounted for: Potash 0.34; water 0.30=0.64						

[1] American Journal of Science and Arts, 1890, Vol. XL, p. 394.

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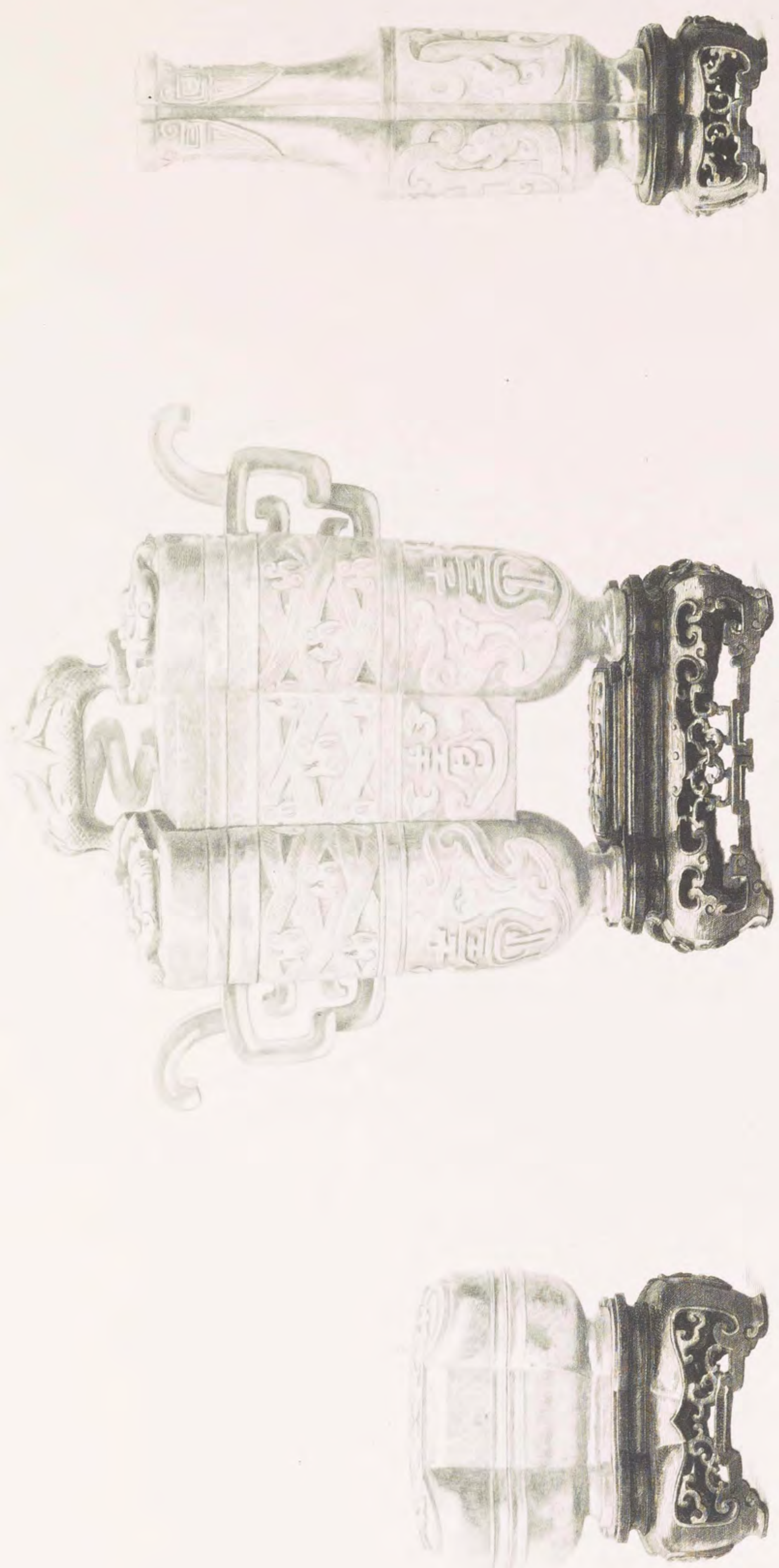
Nos. 675, 676, 677

INCENSE-BURNING SET

(*San Shê*)

Ch'ien-lung (1736–95)

Nephrite



No. 182

		Glaucophane and riebeckite[1]	Nephrite $RSiO_3$	Unaccounted for	Nephrite recalculated	Theory
Specific gravity . .	3.0118					
Silica, SiO_2	57.19	7.44	49.75		57.35	57.69
Alumina, Al_2O_3 . . .	2.24	2.24				
Ferric oxide, Fe_2O_3 .	1.60	1.60				
Ferrous oxide, FeO .	1.10		1.10			
Magnesia, MgO . .	21.97		21.97		28.32	28.85
Lime, CaO	13.16	.73	12.43		14.33	13.46
Soda, Na_2O	.20	.20				
Potash, K_2O	1.44	1.44				
Water, H_2O	1.82		.90	.92		
	100.72	13.65	86.15	.92	100.00	100.00

The foregoing analyses indicate the presence of the well-recognized molecules, glaucophane and riebeckite, and of a silicate of the general formula $RSiO_3$, where R is Mg, Ca, Fe, and H_2. Moreover, if the Fe and H_2 are regarded as taking the place of Mg, the composition approximates to that which is assigned to the crystallized mineral tremolite, $CaMg_3(SiO_3)_4$. The nearly uniform character of the analyses is noticeable. In the few cases where the silica is low (52.98 in No. 322, specific gravity 2.9506; and 52.60 in No. 289, specific gravity 2.9311) the magnesia and water are high, and it is probable that a little serpentine is present.

DESCRIPTIONS OF THE SPECIMENS ANALYZED

WITH ANALYSES, REDUCTIONS, AND NOTES

NUMBER 41. *Fragment* of an ornamental medallion from China. Specific gravity, 3.3303; hardness, 7; translucent Burmese jadeite with remarkably perfect crystalline structure. *Color*, "melting snow."

Microstructure: This is the coarsest-grained variety examined by Professor Iddings. It is an aggregate of colorless crystals that can be seen without the aid of a lens, the largest being three millimetres long. The size of the crystals varies greatly, from that just mentioned to microscopic dimensions, all mingled without definite arrangement or any suggestion of a porphyritic structure. The substance of the jadeite is very pure and free from inclusions in most crystals. A few show specks that seem to be incipient decomposition.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R'''_2R''(SiO_3)_4$	Unaccounted for	Abstract
Silica, SiO_2	57.60	57.26	.34		
Alumina, Al_2O_3 . . .	25.75	24.50	.14	1.11	Jadeite, 97.27
Magnesia, MgO . . .	.13			.13	Pseudo-jadeite, .55
Lime, CaO	.58		.07	.51	Unaccounted for, 2.00
Soda, Na_2O	13.31	13.31			
Potash, K_2O	2.20	2.20			99.82
Water, H_2O	.25			.25	
	99.82	97.27	.55	2.00	

Number 32. *Part* of a cylindrical core of Burmese jadeite. Specific gravity, 3.3269; hardness, 7; coarsely crystalline and of remarkable purity, showing almost entirely isolated crystals in several places. *Color*, white with faint lavender tint.

[1] The prevailing alkali is here potash, and it has been necessary to take some calcium to make up for the deficiency of the combined alkalis.

Microstructure: Irregularly shaped anhedrons of colorless jadeite varying in size from a diameter of one millimetre to microscopic grains.

Foote's analysis is here given, with Clarke's reduction of same:

		Jadeite	Pyroxene	Uncertain	Abstract
Silica, SiO_2	58.86	56.97	1.02	.87	
Alumina, Al_2O_3 . .	25.12	24.14		.98	Jadeite, 95.81
Ferric oxide, Fe_2O_3 .	.16			.16	Pyroxene, 1.85
Ferrous oxide, FeO .	.12		.12		Uncertain, 2.20
Lime, CaO	.44		.44		
Magnesia, MgO . .	.27		.27		99.86
Potash, K_2O . . .	.08	.08			
Soda, Na_2O . . .	14.62	14.62			
Water at 100° . .	.04			.04	
Water at 180° . .	.05			.05	
Water at 180°+ . .	.10			.10	
	99.86	95.81	1.85	2.20	

Number 51. *Fragment* of raw jadeite said to be from Tibet. Specific gravity, 3.3359; hardness, 7; of translucent, homogeneous, and compact material with a decided granular-crystalline structure. *Color*, lavender with opaque white snow-like patches.

Microstructure: Nearly pure jadeite, almost colorless in thin section, with a whitish tinge. It is traversed by numerous irregular cracks, as though the rock had been subjected to crushing. There are minute colorless veins crossing the section independent of the cracks. They are made up of larger crystals of the same mineral as the mass. The whole is an aggregation of irregularly shaped crystals of jadeite, the majority of which are very minute and do not exhibit crystallographic outlines. Scattered through it are microscopically small opaque specks, usually with irregular outline, whose exact character cannot be determined. They are probably magnetite. There are also small crystals of a colorless mineral with index of refraction slightly higher than that of the surrounding jadeite, and having a double refraction about half as great as that of jadeite. It appears to be either a tetragonal or an orthorhombic mineral having the axis of greatest elasticity parallel to the length of the prism. It is so filled with inclusions of jadeite that good interference figures could not be obtained, and hence its uniaxial or biaxial character could not be determined. It is therefore not possible to state its mineral character. The most probable assumption is that it is andalusite. The quantity is not large, so that its presence does not materially affect the character of the rock.

The analysis by Foote, with reduction by Clarke, is as follows:

		Jadeite	$R'''_2 R''(SiO_3)_4$	Unaccounted for	Abstract
Silica, SiO_2	58.80	56.85	1.95		
Alumina, Al_2O_3 . . .	25.37	24.16	.83	.38	Jadeite, 95.71
Ferric oxide, Fe_2O_3 .	.33			.33	Pseudo-jadeite, 3.14
Magnesia, MgO . .	.25		.25		Unaccounted for, 1.32
Lime, CaO	.58		.11	.47	
Soda, Na_2O	14.65	14.65			100.17
Potash, K_2O	.05	.05			
Water, H_2O	.14			.14	
	100.17	95.71	3.14	1.32	

Number 42. *Fragment* of jadeite pendant from China. Specific gravity, 3.3287; hardness, 7; wholly jadeite, evidently from Burma, with no other mineral. The crystals are all quite small, grading from 0.8 millimetre to microscopic. There is a slight central clouding in some crystals and a small amount of crushing. *Color*, light green and light gray.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R'''_2R''(SiO_3)_4$	Excess unaccounted for	Abstract
Silica, SiO_2	58.69	54.59	3.06	1.04	
Alumina, Al_2O_3 . . .	25.56	23.20	1.30	1.06	Jadeite, 92.42
Magnesia, MgO . .	.11		.11		Pseudo-jadeite, 5.05
Lime, CaO	.58		.58		Unaccounted for, 2.27
Soda, Na_2O	13.09	13.09			
Potash, K_2O	1.54	1.54			99.74
Water, H_2O	.17			.17	
	99.74	92.42	5.05	2.27	

Number 362. *Vase*, in the form of blossoming plum-tree trunk, from China. Specific gravity, 3.3316; hardness, 7; of translucent, homogeneous, and compact material, remarkable for its color. *Color*, light gray mottled with blue and marked with a brown (almost amber-colored) staining in parts.

Microstructure: An aggregate of lath-shaped jadeite crystals with jagged outline and somewhat parallel arrangement. In places they are very minute and carry longer crystals of jadeite with no optical distinction. There is a little colorless mineral supposed to be albite.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R'''_2R''(SiO_3)_4$	Excess unaccounted for	Abstract
Silica, SiO_2	58.93	54.10	4.83		
Alumina, Al_2O_3	25.39	22.99	2.05	.50	Normal jadeite, 91.62
Titanic oxide	.15				Pseudo-jadeite, 7.89
Manganous oxide, MnO .	trace				Unaccounted for, .73
Ferric oxide, Fe_2O_3 . . .	trace				
Ferrous oxide, FeO . . .	trace				100.24
Magnesia, MgO	.29		.29		
Lime, CaO	.72		.72		
Soda, Na_2O	12.90	12.90			
Potash, K_2O	1.63	1.63			
Water, H_2O	.23			.23	
	100.24	91.62	7.89	.73	

Number 7. *Fragment* of a boulder from Burma. Specific gravity, 3.3122; hardness, 7; homogeneous and compact. *Color*, light gray with delicate mottlings of sea-green.

Microstructure: A comparatively coarse-grained aggregation of jadeite crystals, the larger of which are 0.6 millimetre in diameter. The rock is colorless in thin section, with small spots of clouded material. It is almost wholly jadeite, the clouded matter being indeterminable and presumably the beginnings of decomposition. The grains or anhedrons of jadeite are irregular and of various sizes. In some cases the prismatic cleavage is distinct. In places there are patches of a colorless mineral with lower index of refraction than that of jadeite, and with the double refraction and polysynthetic twinning of plagioclase feldspar. It acts as a matrix in which small prisms of jadeite lie in all positions, and against which the jadeite is automorphic. It exhibits no signs of alteration, whether of decomposition or of crushing.

The analysis by Foote, with reduction by Clarke, is as follows:

		Jadeite	Albite	Anorthite	Al_2CaSiO_6	$R''SiO_3$	Unaccounted for	Abstract
Silica, SiO_2 . . .	58.58	51.25	3.25	.24	.47	3.37		
Alumina, Al_2O_3 .	23.71	21.78	.92	.20	.81			Jadeite, 86.27
Ferric oxide, Fe_2O_3	.51						.51	Albite, 4.73
Ferrous oxide, FeO	.24					.15	.09	Anorthite, .51
Magnesia, MgO .	1.35					1.35		Al_2CaSiO_6, 1.72
Lime, CaO . . .	1.63			.07	.44	1.12		$R''SiO_3$, 5.99
Soda, Na_2O . . .	13.80	13.24	.56					Unaccounted for, .90
Water, H_2O . . .	.30						.30	100.12
	100.12	86.27	4.73	.51	1.72	5.99	.90	

Number 16. *Slab* of crude jade from Upper Burma. Specific gravity, 3.2578; hardness, 7; of subtranslucent material, coarsely granular in structure, with apparent radiated reflections from one to four millimetres in diameter. *Color*, lavender and gray intermingled with emerald-green and patches of black, clouded with bright lettuce-green and dead black.

The analysis by Walden, with reduction by Penfield, is as follows:

	Lavender	Green	Mixture
Silica, SiO_2	57.79	57.49	57.45
Alumina, Al_2O_3	21.40	21.56	21.94
Ferric oxide, Fe_2O_3	.80	1.05	.91
Ferrous oxide, FeO			
Manganous oxide, MnO	trace	trace	trace
Magnesia, MgO	4.72	4.79	3.96
Lime, CaO	3.06	2.90	3.10
Soda, Na_2O	12.36	11.98	12.13
Potash, K_2O			
Water, H_2O	.76	.45	.79
	100.89	100.22	100.28

	Diopside $CaMg(SiO_3)_2$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Silica, SiO_2	7.80	49.65	57.88	59.40
Alumina, Al_2O_3		21.94	26.24	25.25
Ferric oxide, Fe_2O_3		.91		
Magnesia, MgO	3.00	.96		
Lime, CaO	3.10			
Soda, Na_2O		12.13	15.88	15.35
Potash, K_2O				
Loss on ignition, H_2O				
	13.90	85.59	100.00	100.00

Number 490. *Plate* from China. Specific gravity, 3.3373; hardness, 7; of translucent, very compact, and homogeneous material; remarkably perfect and sharply resonant. *Color*, whitish with green patches.

Microstructure: Wholly jadeite without other mineral, with a slight central clouding in some crystals, and a small amount of crushing.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R''{}'_2R''(SiO_3)_4$	Excess unaccounted for	Abstract
Silica, SiO_2	58.40	49.63	6.21	2.56	
Alumina, Al_2O_3	27.05	21.09	2.64	3.32	Normal jadeite, 84.29
Magnesia, MgO	.57		.57		Pseudo-jadeite, 10.07
Lime, CaO	.65		.65		Unaccounted for, 6.06
Soda, Na_2O	11.37	11.37			
Potash, K_2O	2.20	2.20			100.42
Water, H_2O	.18			.18	
	100.42	84.29	10.07	6.06	

Number 496. *Bowl* from China. Specific gravity, 3.3394; hardness, 7; of translucent, homogeneous, and coarsely crystalline material. *Color*, pale sea-green.

Microstructure: Many large crystals of jadeite up to three millimetres in diameter; undulatory extinction is pronounced, and the rock has evidently been subjected to great strains. Many of the jadeite aggregates are arranged in optical fields often resembling sections of mica. Fine fragments and fibres of jadeite occur in veins and act as a cement.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R''{}'_2R''(SiO_3)_4$	Unaccounted for	Abstract
Silica, SiO_2	58.48	47.85	10.12	.51	
Alumina, Al_2O_3	23.57	20.34	3.23		Jadeite, 81.61
Ferric oxide, Fe_2O_3	1.68		1.68		Pseudo-jadeite, 17.18
Magnesia, MgO	1.33		.53	.80	Unaccounted for, 1.47
Lime, CaO	1.62		1.62		
Soda, Na_2O	10.33	10.33			100.26
Potash, K_2O	3.09	3.09			
Water, H_2O	.16			.16	
	100.26	81.61	17.18	1.47	

K is regarded as replacing Na in jadeite. The other molecule is a jadeite-acmite with lime and magnesia in place of alkalis. Penfield includes it with the jadeite, as is proper.

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No. 622

BUDDHIST BOWL

(*Po*)

Ch'ien-lung (1736–95)

Nephrite

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Number 485. Small *saucer-shaped dish* from China. Specific gravity, 3.3381; hardness, 7; of translucent, homogeneous, and compact material. *Color*, greenish-gray.

Microstructure: An aggregate of jadeite crystals all of which are quite small, grading to microscopic, the longest being about 0.8 millimetre. The lamination is due to the nearly parallel arrangement of some prisms and to the alternation of layers of coarser and finer grains. The rock is very fresh and pure, without other constituent minerals, and there is little or no sign of decomposition or alteration by dynamic forces.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	$R''_2R''(SiO_3)_4$	Unaccounted for	Abstract
Silica, SiO_2	59.02	46.80	12.22		
Alumina, Al_2O_3	24.88	19.89	4.99		Normal jadeite, 79.24
Ferric oxide, Fe_2O_3 . . .	1.23		.33	.90	Pseudo-jadeite, 20.00
Ferrous oxide, FeO . . .	.28		.02	.26	Unaccounted for, 1.23
Manganous oxide, MnO .	.19		.19		
Magnesia, MgO	1.10		1.10		100.47
Lime, CaO	1.15		1.15		
Soda, Na_2O	11.21	11.21			
Potash, K_2O	1.34	1.34			
Water, H_2O	.07			.07	
	100.47	79.24	20.00	1.23	

Number 219. *Axe* from Mexico. Specific gravity, 3.3034; hardness, 7; showing on cut edges a very compact crystalline structure with occasional white markings and veinings which are also visible on the weathered surface. At the lower end there is a cavity seventeen millimetres long by six in width, and more than a dozen smaller ones in various parts, filled with a hard, compact white substance which effervesces readily on the application of hydrochloric acid, proving it to be calcite deposited after the object had been lost or buried in some limestone strata or a limestone cave. *Color*, black.

Microstructure: An aggregate of small jadeite crystals with a few larger ones of irregular shape, parts of some of them being pale green. The mass is streaked with greenish dark-colored specks which appear under the microscope as opaque particles crowded together in the larger jadeite crystals as products of alteration. There are also rather numerous patches of a colorless undeterminable mineral, and small, somewhat lenticular bluish-green crystals which suggest glaucophane.

The analysis by Walden, with reduction by Penfield, is as follows:

		Diopside $Ca(MgFe)(SiO_3)_2$	Ægirite $NaFe(SiO_3)_2$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Silica, SiO_2	56.69	4.98	6.72	44.99	57.85	59.40
Alumina, Al_2O_3 . . .	20.46			20.46	26.31	25.25
Ferric oxide, Fe_2O_3 . .	4.49		4.49			
Ferrous oxide, FeO . .	.75	.75				
Magnesia, MgO . . .	1.64	1.28		.36		
Lime, CaO	3.28	2.29		.99		
Soda, Na_2O	11.65		1.74	9.91	15.84	15.35
Potash, K_2O	1.15			1.15		
Loss on ignition, H_2O .	.48					
	100.59	9.30	12.95	77.86	100.00	100.00

Number 177. *Hatchet* from the lake-dwellings of Neuchâtel, Switzerland. Specific gravity, 3.3745; hardness, 7; opaque, very compact in texture, with a weathered spot at the upper end. *Color*, dark green, almost black.

Microstructure: Very small irregularly shaped crystals or grains of colorless jadeite and also pale-green amphibole, with a crudely parallel orientation, producing a lamination or fibration of the mass. This is further emphasized by streaks of minute grains of an almost colorless mineral with high index of refraction,

and with the characteristics of zircon. There is also a little iron oxide, probably magnetite, in irregularly shaped grains.

The analysis by Foote, with reduction by Clarke, is as follows:

		Jadeite	Fe''_2CaSiO_6	Magnetite?	Nephrite	Unaccounted for	Abstract
Silica, SiO_2	56.08	44.95	1.04		8.91	1.18	
Alumina, Al_2O_3 . . .	19.05	19.05					Jadeite, 75.61
Ferric oxide, Fe_2O_3 . .	3.76		2.82	.94			Fe''_2CaSiO_6, 4.82
Ferrous oxide, FeO . .	2.26			.42	1.84		Magnetite? 1.36?
Magnesia, MgO . . .	2.08				2.08		Nephrite, 16.81
Lime, CaO	4.94		.96		3.98		Unaccounted for, 1.62
Soda, Na_2O	11.61	11.61					
Potash, K_2O	.26					.26	100.22
Water, H_2O	.18					.18	
	100.22	75.61	4.82	1.36	16.81	1.62	

Number 4. *Fragment* of boulder from Burma. Specific gravity, 3.2176; hardness, 7; of coarsely granular structure. On broken surfaces the outlines of many of the pyroxene crystals are clearly visible. On cut surfaces the reflections resemble the frosted appearance of galvanized iron. *Color*, light gray with mottlings of light green.

Microstructure: An aggregation of irregularly shaped crystals of nearly colorless jadeite, with many cracks which follow the outlines of the crystals, the prismatic cleavage, and a transverse parting, probably basal. In places the pyroxene crystals become long prisms and lie at all angles, sometimes grouped in fan-like aggregation-bundles. In several places they lie embedded in a colorless mineral which acts as a matrix for them. In these they have sharply defined crystal forms. This colorless matrix appears to consist of relatively large individuals, not an aggregate of small ones. It has a low index of refraction and very low double refraction, and shows some polysynthetic lamellæ. Its exact nature is not determinable by optical means alone. It is possibly analcite.

The analysis by Walden, with reduction by Penfield, is as follows:

		Diopside $CaMg(SiO_3)_2$	Analcite $NaAl(SiO_3)+H_2O$	Jadeite $NaAl(SiO_3)_2$	Jadeite calculated to 100%	Jadeite theory
Silica, SiO_2	58.41	1.50	15.84	41.07	58.37	59.40
Alumina, Al_2O_3 . . .	24.64		6.73	17.91	26.05	25.25
Ferric oxide, Fe_2O_3 . .	.67			.67		
Magnesia, MgO . . .	1.24	.52		.72		
Lime, CaO	1.43	.67		.76		
Soda, Na_2O	12.76		4.09	8.67	15.58	15.35
Potash, K_2O	.58			.58		
Loss on ignition, H_2O .	1.19		1.19			
	100.92	2.69	27.85	70.38	100.00	100.00

Number 18. *Fragment* of boulder from Burma. Specific gravity, 3.1223; hardness, 7; of subtranslucent material, with a crystalline interwoven structure of interlacing patches of an intense emerald-green and an almost white mineral. *Color*, lettuce-green.

Microstructure: The prisms are acicular and fibrous. There is more of an approach to streaked or parallel fibrous structure, though the needles cross one another at various angles. The amphibole has a pale-green color in thin section, the crystals being pleochroic, yellowish-green parallel to the prism axis and bluish-green at nearly right angles. It is a mixture of jadeite and amphibole in the proportion of three to two, and consists of very minute fibres with a preponderating parallel arrangement, producing a more or less pronounced fibration or lamination in the rock.

The analysis by Foote, with reduction by Clarke, gave the following results:

		Jadeite	Ægirite	Amphibole	Reduced	Calculated	Abstract	
Silica, SiO_2	57.36	33.16	2.05	22.15	58.74	58.39		
Alumina, Al_2O_3 . . .	14.01	14.01					Amphibole,	38.79
Ferric oxide, Fe_2O_3 .	1.37		1.37				Jadeite,	55.68
Ferrous oxide, FeO .	.79			.79			Ægirite,	3.99
Magnesia, MgO . .	11.07			11.07	34.13	34.07	Excess water,	1.45
Lime, CaO	1.91			1.91				
Soda, Na_2O	11.32	8.51	.57	2.24	6.86	7.54		99.91
Potash, K_2O	.53			.53				
Water, H_2O	1.55			.10	.27			
	99.91	55.68	3.99	38.79	100.00	100.00		

The amphibole is unusual. In the reduced column Fe and Ca are reduced to terms of Mg, and K to Na, then all to one hundred per centum. The calculated column is computed for $Na_2Mg_7(SiO_3)_8$. This amphibole may be new.

Number 303. *Mask* from Mexico. Specific gravity, 2.8320; hardness, 7; subtranslucent, fairly compact granular material. *Color*, light emerald-green and gray, with seams of gray-brown, and light green on the back.

Microstructure: Irregularly shaped crystals of jadeite scattered through albite, which forms interlocking crystals of variable size, some individuals enclosing a number of crystals of jadeite. The albite is pure and fresh and exhibits a characteristic cleavage and optical properties. Twinning in polysynthetic lamellæ is developed to only a limited extent. Many crystals are not twinned.

The analysis by Walden, with reduction by Penfield, is as follows:

		Nephrite $CaMg(SiO_3)_2$	Jadeite $NaAl(SiO_3)_2$	Albite $NaAlSi_3O_2$	Theoretical comparison of a mixture of Nephrite	Jadeite	Albite
Silica, SiO_2	63.47	2.20	28.80	32.47	2.17	28.87	32.48
Alumina, Al_2O_3 . . .	20.76		11.53	9.23		12.43	9.20
Ferric oxide, Fe_2O_3 .	1.27		1.27				
Magnesia, MgO . .	1.11	1.11			1.08		
Lime, CaO	1.16	.50	.66		.50		
Soda, Na_2O	11.98		6.63	5.35		7.46	5.81
Potash, K_2O	.34			.34			
Water, H_2O	.36						
	100.45	3.81	48.89	47.39	3.75	48.76	47.49

The analysis indicates the presence of a little nephrite.

Number 317. Part of a *kuei*, or sceptre, from China. Specific gravity, 2.9430; hardness, 6.5; a tomb piece. *Color*, light grayish-yellow heavily stained with dead-oak-leaf coloring.

Microstructure: Consists of minutely fibrous amphibole, and considerable compact amphibole in irregularly shaped crystals, in clusters and streaks through the rock. There are also remnants of small jadeite crystals in aggregations and streaks and sometimes in spherulitic clusters.

The analysis by Walden, with reduction by Clarke, is as follows:

		Doubtful	Nephrite
Silica, SiO_2	57.37	.58	56.79
Alumina, Al_2O_3 . . .	1.03	1.03	
Iron oxides, Fe_2O_3 . .	.78	.78	
Magnesia, MgO . . .	23.96		23.96
Lime, CaO	13.03		13.03
Alkalis	undet.	?	
Water, H_2O	3.63	1.57	2.06
	99.80	3.96	95.84

Iddings's work shows that the material was once jadeite, but is mainly altered to amphibole. The alumina corresponds to about four per centum jadeite.

Number 79. *Section of water-worn boulder* from Khotan, Chinese Turkistan. Specific gravity, 2.9168; hardness, 6.5; translucent, compact, and homogeneous. In general appearance the specimen might be mistaken for a quartzite boulder. *Color*, very dark gray, almost black; known among the Chinese as *mo-yü*, or "ink-jade."

Microstructure: A fine felt of minute scales; some small patches with nearly parallel fibres suggest former jadeite crystals. Numerous opaque microscopic crystals are arranged in streaks to some extent, and have a yellowish metallic lustre in sunlight. Their form appears to be orthorhombic, and they may be (?) marcasite or (?) arsenopyrite.

Foote's chemical analysis, with Clarke's reduction, is here given:

		$(NaK)AlSi_2O_6$	$R''{}'_2CaSiO_6$	Nephrite	Abstract	
Silica, SiO_2	57.14	.66	.42	56.06		
Alumina, Al_2O_3	1.20	.56	.64		Nephrite,	95.83
Ferric oxide, Fe_2O_3	.12		.12		$R'AlSi_2O_6$,	1.59
Ferrous oxide, FeO	.21			.21	$R''{}'_2CaSiO_6$,	1.57
Manganous oxide, MnO	.04			.04	Excess water,	.95
Lime, CaO	12.65		.39	12.26		99.94
Magnesia, MgO	25.67			25.67		
Soda, Na_2O	.29	.29				
Potash, K_2O	.08	.08				
Water at 100°	.38					
Water at 180°	.27					
Water at 180°+	1.89			1.59		
	99.94	1.59	1.57	95.83		

Number 153. *Crude fragment* from Jade Mountain, Alaska. Specific gravity, 2.9487; hardness, 5.5; structure, strongly foliated and in part fine-grained, compact, and tenacious. One end is altered to a white, almost steatitic mass with a hardness of not over 2, suggesting weathering or fire-mining. *Color*, sage-green.

Microstructure: An aggregation of extremely fine fibres that lie parallel to one another and have been bent into contorted and crenulated bands. There is some clouding of the material, which is white by incident light and yellowish by transmitted light. In places the fibres are less crinkled and the substance is nearly transparent, and the double refractions are more uniform as shown by the interference colors, but there is some mottling. The thin section cut across the fibres shows less crinkling and a less fibrous texture, and indicates that the fibres are flattened or bladed. Very free from inclusions of other minerals.

The chemical analysis by Foote, and reduction by Clarke, gave the following:

		$NaAlSi_2O_6$	$R''{}'_2CaSiO_6$	Nephrite	Abstract	
Silica, SiO_2	57.09	.81	.41	55.87		
Alumina, Al_2O_3	.53	.34	.19		Nephrite,	95.58
Ferric oxide, Fe_2O_3	.81		.81		$NaAlSi_2O_6$,	1.36
Ferrous oxide, FeO	3.98			3.98	$R''{}'_2CaSiO_6$,	1.79
Magnesia, MgO	22.28			22.28	Excess water,	1.49
Lime, CaO	11.75		.38	11.37		
Soda, Na_2O	.21	.21				100.22
Water, H_2O	3.57			2.08		
	100.22	1.36	1.79	95.58		
Nephrite = $H_4Ca_4(MgFe)_{12}(SiO_3)_{18}$.						

Number 78. *Portion of boulder* from Chinese Turkistan. Specific gravity, 2.9832; hardness, 6.5; translucent, homogeneous, and compact, showing on the exterior reflections of sinewy veinings. *Color*, sage-green with black specks.

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No. 614

DOUBLE-CYLINDER VASE

(*Shuang Kuan P'ing*)

Ch'ien-lung (1736–95)

Nephrite

Microstructure: A fine-grained felt of scales and fibres with streaks or veins of larger blades in crystals nearly parallel to one another. There are minute areas and streaks of colorless (?) clinochlore. There are besides a few opaque grains of a mineral dark reddish-brown in thin edges. The grains are much cracked and traversed by amphibole. The mineral may be chromite, traces of chromium being found upon analysis.

Foote's analysis, with Clarke's reduction of same, is here given:

		$(NaK)AlSi_2O_6$	Chromite	R'''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	56.43	.75		.52	55.16		
Alumina, Al_2O_3	.88	.32		.56		Nephrite,	95.32
Chromic oxide, Cr_2O_3 . .	.15		.15			R'''_2CaSiO_6,	2.11
Ferric oxide, Fe_2O_3 . .	.54			.54		Chromite,	.22
Ferrous oxide, FeO . .	3.62		.07		3.55	$R'AlSi_2O_6$,	1.29
Manganous oxide, MnO .	.07				.07	Excess water,	.92
Nickel protoxide, NiO .	.06				.06		
Lime, CaO	12.85			.49	12.36		99.86
Magnesia, MgO	22.68				22.68		
Potash, K_2O	.07	.07					
Soda, Na_2O	.15	.15					
Water at 100°	.30						
Water at 180°	.14						
Water at 180°+	1.92				1.44		
	99.86	1.29	.22	2.11	95.32		

Number 155. *Crude fragment* from Jade Mountain, Alaska. Specific gravity, 2.9604; hardness, 6.5. The specimen shows contact markings with slight traces of slickensides, is closely foliated in part, enclosing rounded protuberant masses in the foliation. It is stained more or less with small brownish spots which are probably the alteration of some included mineral. *Color,* olive-green; grayish-green on fractured surfaces.

Microstructure: Confused fibres of amphibole, extremely minute, crinkled and contorted in some places, in streaks of parallel fibres in others. The fibres are so minute that they overlie one another in the thin section and produce aggregate polarizations between crossed nicols. It is traversed by short crooked cracks containing dark coloring matter. The nephrite is stained yellow with streaks of brown.

The chemical analysis by Foote, with Clarke's reduction of same, is here given:

		$NaAlSi_2O_6$	R'''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	57.02	.85	.58	55.59		
Alumina, Al_2O_3	.70	.36	.34		Nephrite,	95.57
Ferric oxide, Fe_2O_3	1.04		1.04		$NaAlSi_2O_6$,	1.43
Ferrous oxide, FeO	4.33			4.33	R'''_2CaSiO_6,	2.50
Magnesia, MgO	21.56			21.56	Excess water,	1.01
Lime, CaO	12.63		.54	12.09		
Soda, Na_2O	.22	.22				100.51
Water, H_2O	3.01			2.00		
	100.51	1.43	2.50	95.57		

Number 234. *Chisel* from British Columbia. Specific gravity, 2.9987; hardness, 6.5; of translucent and very compact material, showing, where sawn, a very characteristic splintery structure. *Color,* mottled grayish-green with black veinings.

Microstructure: A confused aggregation of amphibole fibres, with occasional longer streaks of nearly parallel fibres, and a faint suggestion of patches derived from previous pyroxene.

The analysis by Foote, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	Al_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	56.70	.55	1.05	55.10		
Alumina, Al_2O_3 . .	2.01	.23	1.78		Nephrite,	95.05
Ferric oxide, Fe_2O_3 .					$NaAlSi_2O_6$,	.92
Ferrous oxide, FeO .	5.09			5.09	Al_2CaSiO_6,	3.81
Magnesia, MgO . .	21.91			21.91	Excess water,	.75
Lime, CaO	12.12		.98	11.14		
Soda, Na_2O	.14	.14				100.53
Water, H_2O	2.56			1.81		
	100.53	.92	3.81	95.05		

The nephrite $= H_4Ca_4(MgFe)_{13}(SiO_3)_{19}$.

Number 330. *Thumb-ring* from China. Specific gravity, 2.9896; hardness, 6.5; horny, compact, with scattered fragmentary highly striated crystals of colorless jadeite. *Color*, gray clouded and veined with very dark brown.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	Nephrite	Abstract	
Silica, SiO_2	57.02	2.47	54.55		
Alumina, Al_2O_3	1.05	1.05		Nephrite,	94.33
Ferric oxide, Fe_2O_3 } Ferrous oxide, FeO } .	1.05		.55 ? .50 ?	Jadeite, Excess water,	4.15 2.05
Magnesia, MgO	23.01		23.01		
Lime, CaO	14.77		14.77		100.53
Alkalis	undet.	Na_2O .63 ?			
Water, H_2O	3.00		.95		
	99.95	4.15	94.33		

Jadeite is assumed to be proportional to alumina, and the undetermined soda is calculated to correspond. Ferrous and ferric oxide not separated by the analyst.

Number 83. *Fragment* of oblong medallion from China. Specific gravity, 2.9546; hardness, 6.5; of very pure, translucent, and compact material, with splintery fracture. *Color*, sage-green.

Microstructure: There is a faint suggestion of patches derived from a previous pyroxene, but the amphibole fibres are in confused aggregation, with occasional longer streaks of nearly parallel fibres.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	R'''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	57.38	1.28	.81	55.29		
Alumina, Al_2O_3 . . .	.83	.54	.29		Nephrite,	92.81
Ferric oxide, Fe_2O_3 .	1.71		1.71		$NaAlSi_2O_6$,	2.15
Magnesia, MgO . .	23.37			23.37	R'''_2CaSiO_6,	3.57
Lime, CaO	13.12		.76	12.38	Excess water,	1.72
Soda, Na_2O	.33	.33				
Water, H_2O	3.51			1.79		100.25
	100.25	2.15	3.57	92.83		

Number 458. *Little figure* from China. Specific gravity, 2.9490; hardness, 6.5; of translucent, homogeneous, and compact material, in which are seen by transmitted light some subtranslucent inclusions, evidently another form of nephrite. *Color*, yellow with a greenish tint.

The analysis by Walden, with reduction by Clarke, is as follows:

		R'''_2CaSiO_6	Serpentine	Nephrite	Abstract	
Silica, SiO_2	54.44	.62	.84	52.98		
Alumina, Al_2O_3 . . .	.82	.82			Nephrite,	92.72
Ferric oxide, Fe_2O_3 .	.38	.38			Serpentine,	1.93
Ferrous oxide, FeO .	.34			.34	R'''_2CaSiO_6,	2.40
Magnesia, MgO . .	25.88		.84	25.04	Excess water,	3.23
Lime, CaO	13.70	.58		13.12		
Soda, Na_2O	.70			.70		100.28
Potash, K_2O . . .	.54			.54		
Water, H_2O	3.48		.25			
	100.28	2.40	1.93	92.72		

The low silica indicates serpentine. Without it bases are in excess of silica.

Number 134. *A huge block*, weighing 2140 kilos, discovered in 1899 by Mr. George F. Kunz, near the village of Jordansmühl, Silesia. Several specimens were detached from different parts of the block for investigation:

A. Specific gravity, 2.9044; hardness varies from 6.5 to 5. *Color*, impure gray mottled with pale-green, and dark, almost black spots. Structure, splintery and horn-like, but showing between the laminæ a slight alteration.

B. A slab of somewhat darker color and more uniform. Specific gravity (average of three separate quantities), 2.9527; hardness, 6.5. Fine and coarse material intermingled, but in different ways and in different proportions, showing a different structure in different parts.

C. A thick rectangular slab showing a darker, more uniform spinach-green color, thickly mottled in parts with very dark-green patches, almost black, and occasional spots of a dark metallic substance. The material is fine-grained and shows the characteristic horn-like texture of nephrite. Specific gravity, 2.9960; hardness, 6.5.

Two microsections from the sample marked A and two from sample C were studied by Professor Iddings, whose reports are here given:

A. A fibrous nephrite with very fine texture. There are occasional small areas of a colorless mineral, apparently fibrous or in minute scales, having lower refraction than nephrite and about the same double refraction as quartz, possibly a little higher. It appears nearly uniaxial in some cases, and distinctly biaxial in others, is optically positive, and is probably a chloritic mineral. There are also occasional spots formed of a cloud of opaque dot-like particles and some that are possibly magnetite.

C. The rock consists of an aggregation of microscopic scales and fibres of amphibole (nephrite) and patches of sub-parallel fibres in all positions; a few larger patches of the same; some scattered acicular crystals of colorless amphibole (nephrite) with characteristic cross-section and prismatic cleavage. The refraction of all these forms of amphibole is alike. No chromite occurs in the sections.

Three thin sections of sample B were studied by Professor Max Bauer. In the first section he found an exceedingly fine structure, the fibres strongly bent and curved and lying in all directions, forming a felt-like texture; actinolite prisms fairly numerous, the largest measuring two and a half millimetres in length and half a millimetre thick, but the majority small. The angles of extinction of the prisms never exceed 15°. The second section exhibits a much less fine-fibrous structure, and consists of fairly long-fibred tufts or bundles which are often contorted, and which contain in the centre a compact kernel consisting of an actinolite prism. The bundles lie for a considerable distance nearly parallel with each other. In the third section a coarser structure is seen, and nearly all the fibre-bundles have the same compact kernel of actinolite, ravelled at the side and consequently in course of transition into the surrounding material, which consists only of fibres. A few of the smaller tufts lack the compact kernel of actinolite.

The substance of the nephrite is very pure. A few small inclusions are found, which form insignificant aggregates in a few places. There are also a few very small colorless grains whose substance cannot be determined with certainty.

Material from each of these three samples was analyzed:

A. By Dr. George Steiger of the United States Geological Survey, Washington, D. C.

B. By Dr. Carl Busz of Münster, Westphalia, Germany.

C. By Dr. Harry W. Foote of Yale University.

They are here given, with Clarke's reductions:

A.—STEIGER, ANALYST

		Amphibole	R'''_2CaSiO_6	Unaccounted for	Abstract
Silica, SiO_2	56.39	54.79	1.60		
Alumina, Al_2O_3 . . .	1.63		1.63		Amphibole, 92.21
Ferric oxide, Fe_2O_3 . .	1.72		1.72		R'''_2CaSiO_6, 6.44
Ferrous oxide, FeO . .	3.70	3.70			Unaccounted for, 1.80
Manganous oxide, MnO	.26	.26			
Nickel protoxide, NiO .	.13	.13			100.45
Magnesia, MgO . . .	24.63	24.63			
Lime, CaO	7.92	6.43	1.49		
Potash, K_2O	none				
Soda, Na_2O	none				
Water below 100° . .	.65			.65	
Water above 100° . .	3.42	2.27		1.15	
Phosphoric oxide, P_2O_5	trace				
Titanic oxide, TiO_2 . .	trace				
	100.45	92.21	6.44	1.80	

Amphibole much richer in MgO than ordinary nephrite. State of water uncertain. Part of it may be in decomposition products like talc or serpentine.

B.—BUSZ, ANALYST

		Amphibole	R'''_2CaSiO_6	Unaccounted for	Abstract
Silica, SiO_2	52.58	47.97	4.61		
Titanic oxide, TiO_2 .	.12			.12	Amphibole, 79.58
Alumina, Al_2O_3 . . .	6.74		6.74		R'''_2CaSiO_6, 18.41
Ferric oxide, Fe_2O_3 . .	2.76		2.76		Unaccounted for, 2.40
Ferrous oxide, FeO . .	1.72	1.72			
Manganous oxide, MnO	trace				100.39
Lime, CaO	9.84	5.54	4.30		
Magnesia, MgO . . .	21.02	21.02			
Soda, Na_2O	.54	.54			
Potash, K_2O	.28	.28			
Water at 100°. . . .	.21			.21	
Water at 180°. . . .	.19			.19	
Water at red heat . .	3.07 }	2.51		1.88	
Water at blast . . .	1.32 }				
	100.39	79.58	18.41	2.40	

Here again the amphibole is different from normal nephrite. R'''_2CaSiO_6 in excessive amount. Water doubtful. Is serpentine or talc present?

C.—FOOTE, ANALYST

		$R'R'''Si_2O_6$	$(R'_2R'')SiO_3$	Abstract
Silica, SiO_2	56.74	3.51	53.23	
Alumina, Al_2O_3	.93	.93		$R'R'''Si_2O_6$, 5.74
Chromic oxide, Cr_2O_3 . .	.13	.13		Nephrite, $(R'_2R'')SiO_3$, } 93.01
Ferric oxide, Fe_2O_3 . . .	.75	.75		
Ferrous oxide, FeO . . .	3.64		3.64	Excess water, 1.07
Manganous oxide, MnO .	.06		.06	
Nickel protoxide, NiO . .	.09		.09	99.82
Magnesia, MgO	21.75		21.75	
Lime, CaO	13.09		13.09	
Soda, Na_2O	.22	.22		
Potash, K_2O	trace			
Water at 100°	.45			
Water at 180°	.25			
Water above 180° . . .	1.72	.20	1.15	
	99.82	5.74	93.01	

R'_2 = H with bases—that is, water.

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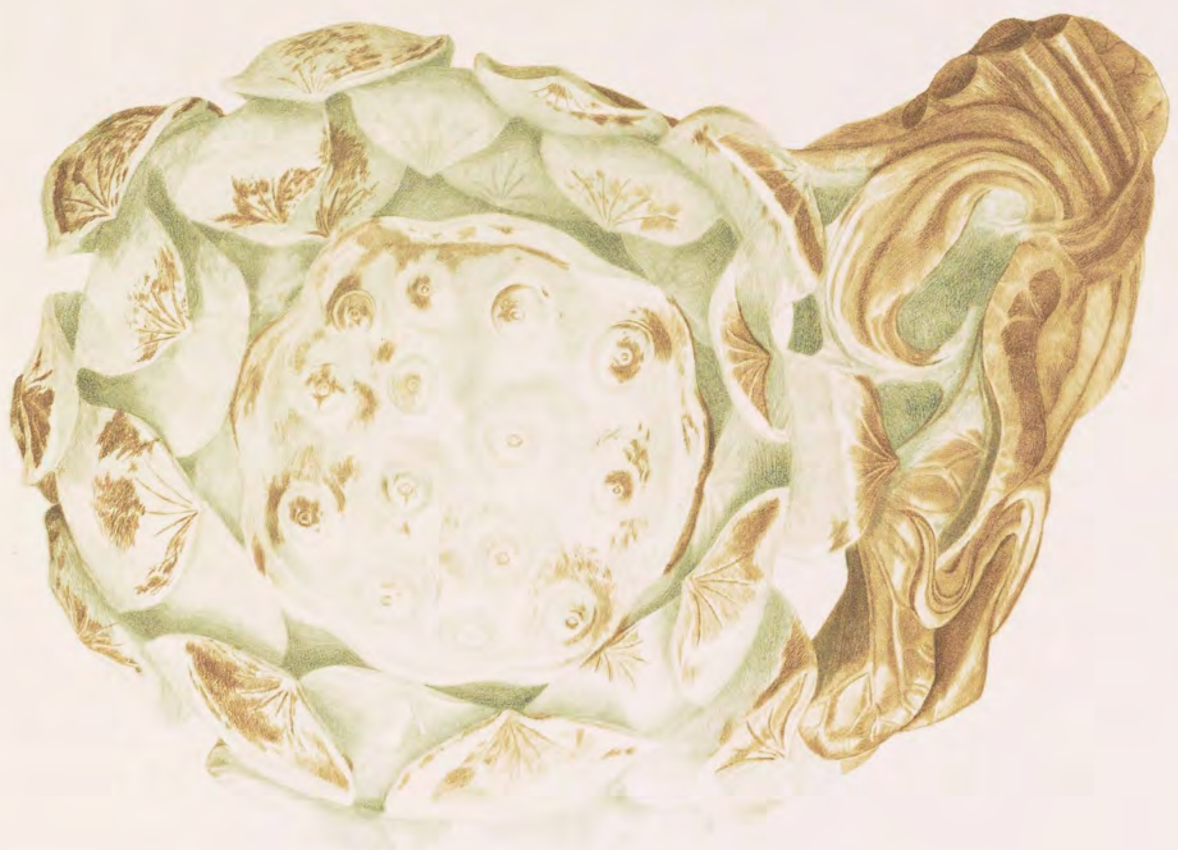
No. 407

WATER RECEPTACLE

(*Shui Ch'êng*)

Ming Dynasty (1368–1644)

Nephrite



Number 618. *Vase* from China. Specific gravity, 2.9513; hardness, 6.5; of translucent, compact material, the sinewy texture of which is well shown by transmitted light. *Color*, white with light-greenish tint.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite?	Ægirite?	Nephrite	Abstract	
Silica, SiO_2	57.28	3.43	.84	53.01		
Alumina, Al_2O_3	1.46	1.46			Nephrite,	92.48
Ferric oxide, Fe_2O_3	.56		.56		Jadeite?	5.77
Ferrous oxide, FeO	1.19			1.19	Ægirite?	1.62
Manganous oxide, MnO	.28			.28	Excess water,	.56
Magnesia, MgO	20.88			20.88		
Lime, CaO	13.15			13.15		100.43
Soda, Na_2O	2.61	.88	.22	1.51		
Potash, K_2O	1.23			1.23		
Water, H_2O	1.79			1.23		
	100.43	5.77	1.62	92.48		

Here the excess of alkalis replaces magnesia in the nephrite.

Number 180. *Hatchet* from the lake-dwellings at Neuchâtel, Switzerland. Specific gravity, 3.0034; hardness, 6.5; of subtranslucent material with a compact, interwoven, laminated structure made up of so many fine laminæ that a beautiful sheen is seen transversely across the left side. *Color*, olive-green.

Microstructure: The rock gives evidence of having been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism. The fibres are almost perfectly parallel, with striations that seem to be due to twinning parallel to the orthopinacoid. The structure resembles that of silicified wood in longitudinal section.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	$NaFeSi_2O_6$	Nephrite	Abstract	
Silica, SiO_2	55.48	1.91	1.35	52.22		
Alumina, Al_2O_3	.89	.89			Nephrite,	92.09
Ferric oxide, Fe_2O_3	.90		.90		$NaAlSi_2O_6$,	3.29
Ferrous oxide, FeO	3.47			3.47	$NaFeSi_2O_6$,	2.62
Magnesia, MgO	22.69			22.69	Excess water,	2.68
Lime, CaO	12.89			12.89		
Soda, Na_2O	.80	.49	.31			100.68
Potash, K_2O	.44		.06	.38		
Water, H_2O	3.12			.44		
	100.68	3.29	2.62	92.09		

Number 81. *Broken medallion* from China. Specific gravity, 2.9510; hardness, 6.5; compact, homogeneous, splintery structure; apparently no inclusions. *Color*, white with faint grayish tint.

Microstructure: A microcrystalline to microcryptocrystalline aggregation of fibres of colorless amphibole that extinguish light between crossed nicols in irregular patches, showing that the original rock was a coarse-grained jadeite.

The analysis by Walden, with reduction by Clarke, is as follows:

		Al_2CaSiO_6	Fe_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	57.77	1.47	.91	55.39		
Alumina, Al_2O_3	2.50	2.50			Nephrite,	91.21
Ferric oxide, Fe_2O_3	2.76		2.43		Fe_2CaSiO_6,	4.19
Magnesia, MgO	20.91			20.91	Al_2CaSiO_6,	5.34
Lime, CaO	13.61	1.37	.85	11.39	Excess Fe_2O_3,	.33
Water, H_2O	3.52			3.52		
	101.07	5.34	4.19	91.21		101.07

Computation uncertain. Absence of alkalis seems to render the hornblendic molecule R_2CaSiO_6 necessary.

Number 67. *Section of crude block* from Khotan, Chinese Turkistan. Specific gravity, 2.9102; hardness, 6.5; tough, horny character of the material very apparent on fractured edges and from internal reflections. *Color*, white with light-greenish tint.

Microstructure: An irregular texture mostly fine-grained, microcrystalline to microcryptocrystalline. In places there is a spherulitic fibrous texture in areas suggesting former coarse-grained rock. There are a few small crystals of muscovite, with bent laminæ having fibrous edges, and intercalated lenses of amphibole. There are some apatite crystals cracked and traversed by amphibole. Both the muscovite and apatite appear to be remnants of a rock metamorphosed to nephrite. Patches with yellowish opaque grains of highly refracting mineral are indeterminable.

A chemical analysis made by Foote, with Clarke's reduction of same, is here given:

		$(NaK)AlSi_2O_6$	R'''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	55.93	2.02	.50	53.41		
Alumina, Al_2O_3 . . .	1.64	.86	.78		Nephrite,	91.65
Ferric oxide, Fe_2O_3 . .	.12		.12		R'''_2CaSiO_6,	1.86
Ferrous oxide, FeO .	.29			.29	$(NaK)AlSi_2O_6$,	3.47
Manganous oxide, MnO	.16			.16	Excess water,	2.82
Lime, CaO	11.59		.46	11.13		99.80
Magnesia, MgO . . .	26.05			26.05		
Potash, K_2O	.19	.19				
Soda, Na_2O	.40	.40				
Water at 100° . . .	.52					
Water at 180° . . .	.32					
Water over 180° . .	2.59			.61		
	99.80	3.47	1.86	91.65		

Number 160. *Slab* from New Zealand. Specific gravity, 3.0103; hardness, 6.5. This is a section of a boulder with part of the weathered surface still remaining at one end. It is remarkably free from metallic inclusions of every kind, and is highly translucent, compact, and homogeneous, admitting of a very high polish. *Color*, seaweed-green.

Microstructure: Fibres in parallel, sometimes in curved arrangement with a parallel or laminated structure strongly marked, and often accompanied by crooked cracks. The rock appears to have been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism.

The analysis by Walden, with reduction by Clarke, is as follows:

		$AlNaSi_2O_6$	$(AlFe)_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	58.14	1.40	4.50	52.24		
Alumina, Al_2O_3 . . .	.98	.59	.39		Nephrite,	89.52
Ferric oxide, Fe_2O_3 . .	3.39		3.39		$AlNaSi_2O_6$,	2.35
Ferrous oxide, FeO .	.85			.85	$R'''_2(SiO_3)_3$,	8.28
Manganous oxide, MnO	.22			.22	Excess water,	.39
Magnesia, MgO . . .	22.38			22.38		
Lime, CaO	12.53			12.53		100.54
Soda, Na_2O	.36	.36				
Water, H_2O	1.69			1.30		
	100.54	2.35	8.28	89.52		
Nephrite = $H_2Ca_3Mg_8(SiO_3)_{12}$ or $Ca(H_2Mg)_3(SiO_3)_4$.						

Number 183. *Hatchet* from the Swiss lake-dwellings. Specific gravity, 2.9836; hardness, 6.5; two sides flat and free from stains, two stained to some depth. *Color*, light green.

Microstructure: Fibres parallel, slightly curved; the laminated structure is strongly marked and accompanied by crooked cracks. It has the appearance of having been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaFeSi_2O_6$	$R'''_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	58.66	1.86	1.46	51.25		
Alumina, Al_2O_3 . . .	.50		.50		Nephrite,	90.64
Ferric oxide, Fe_2O_3 . .	1.76	1.24	.52		$NaFeSi_2O_6$,	3.58
Ferrous oxide, FeO .	3.48			3.48	$R'''_2(SiO_3)_3$,	2.48
Manganous oxide, MnO	.02			.02	Excess silica,	4.09
Magnesia, MgO . . .	22.43			22.43	Excess potash,	.10
Lime, CaO	13.34			13.34		
Soda, Na_2O	.48	.48				100.89
Potash, K_2O	.10					
Water, H_2O	.12			.12		
	100.89	3.58	2.48	90.64		

This nephrite carries an excess of silica over bases.

Number 765. *Sword-guard* from India. Specific gravity, 3.0783; hardness, 6.5; of subtranslucent, very homogeneous, and remarkably compact material, with a vein-like fracture running parallel with the width of the guard. *Color*, very dark greenish-black.

Microstructure: A nearly uniform mixture of amphibole fibres in fan-shaped divergent clusters sometimes approaching a spherulitic arrangement.

The analysis by Foote, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	$R'''_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	55.51	1.59	4.35	49.57		
Alumina, Al_2O_3 . . .	1.72	.67	1.05		Nephrite,	89.78
Ferric oxide, Fe_2O_3 . .	1.33		1.33		$NaAlSi_2O_6$,	2.67
Ferrous oxide, FeO .	7.69			7.69	$R'''_2(SiO_3)_3$,	6.73
Magnesia, MgO . . .	18.80			18.80	Excess water,	1.27
Lime, CaO	13.17			13.17		
Soda, Na_2O	.41	.41				100.45
Water, H_2O	1.82			.55		
	100.45	2.67	6.73	89.78		

The excess of alumina and ferric oxide over the molecule $NaAlSi_2O_6$ is reckoned as the silicate $(AlFe)_2(SiO_3)_3$. This may be regarded also as part of the nephrite.

Number 97. *Fragment* of boulder from China (probably Turkistan). Specific gravity, 2.9825; hardness, 6.5; translucent, compact, splintery structure, with very fine-grained texture on cut surfaces. One half of the mass has been polished by attrition in the river and stained by oxidation of iron and other minerals. *Color*, light sage-green.

Microstructure: A confused aggregate of amphibole fibres that in places reach the size of compact crystals, with a few fragments of jadeite remaining.

The analysis given below is by Walden, the reduction by Clarke:

		Jadeite	$R'''_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	58.59	4.33	1.95	52.31		
Alumina, Al_2O_3 . . .	2.33	1.84	.49		Nephrite,	89.02
Ferric oxide, Fe_2O_3 . .	.97		.97		Jadeite,	7.36
Ferrous oxide, FeO .	.11			.11	$R'''_2(SiO_3)_3$,	3.41
Manganous oxide, MnO	.35			.35		
Magnesia, MgO . . .	22.30			22.30		99.79
Lime, CaO	12.41			12.41		
Soda, Na_2O	.98	.98				
Potash, K_2O	.21	.21				
Water, H_2O	1.54			1.54		
	99.79	7.36	3.41	89.02		

Nephrite = $Ca(H_2Mg)_3(SiO_3)_4$.

Number 581. *Screen* from China. Specific gravity, 2.9609; hardness, 6.5; translucent, compact, homogeneous, with white mottlings or inclusions that are almost opaque and are evidently nephrite. *Color*, white with light-greenish tint.

Microstructure: Clearly the result of amphibolic alteration of jadeite. The rock consists of microcrystalline to microcryptocrystalline aggregations of fibres of colorless amphibole that extinguish light between crossed nicols in irregular patches, some of which are banded in parallel lines. These correspond to the originally twinned pyroxenes. In places the amphibole is in compact crystals. A few small clouded spots appear to be impure muscovite.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	R''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	56.66	4.49	.70	51.47		
Alumina, Al_2O_3 . . .	2.74	1.91	.83		Nephrite,	88.20
Ferric oxide, Fe_2O_3 . .	.56		.56		Jadeite,	7.56
Ferrous oxide, FeO . .	.51			.51	R''_2CaSiO_6,	2.74
Magnesia, MgO . . .	23.42			23.42	Excess water,	1.30
Lime, CaO	12.52		.65	11.87		
Soda, Na_2O	1.16	1.16				99.80
Water, H_2O	2.23			.93		
	99.80	7.56	2.74	88.20		

Nephrite = $H_2Ca_4Mg_{11}(SiO_3)_{16}$ or $Ca(H_2Mg)_3(SiO_3)_4$.

Number 80. *Medallion* with carving of dragon-heads from China. Specific gravity, 2.9706; hardness, 6.5; remarkably pure and homogeneous, exhibiting a characteristic splintery fracture when broken. *Color*, white with faint grayish tint.

Microstructure: Considerable parallelism is seen in the fibres in places, and there are traces of the original pyroxenic grains in the arrangement of the fibres. Prismatic crystals of amphibole are abundant and lie in several directions.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	$R'''_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	57.82	1.20	5.72	50.90		
Alumina, Al_2O_3 . . .	1.14	.51	.63		Nephrite,	86.89
Ferric oxide, Fe_2O_3 . .	4.10		4.10		$R'''_2(SiO_3)_3$,	10.45
Magnesia, MgO . . .	20.49			20.49	$NaAlSi_2O_6$,	2.02
Lime, CaO	13.93			13.93	Excess water,	1.51
Soda, Na_2O	.31	.31				
Water, H_2O	3.08			1.57		100.87
	100.87	2.02	10.45	86.89		

State of iron uncertain. If ferrous the summation would be 0.41 lower, and better. Nephrite would then be about seven per centum higher.

Number 443. *Vase* from China. Specific gravity, 2.9550; hardness, 6.5; of a translucent, homogeneous, and compact material with several inclusions, two to three millimetres in width, of a delicate grayish-brown color. *Color*, white with light-greenish tint.

Microstructure: A uniform aggregation of minute fibres. In the finer-grained portion are groups of compact amphiboles yielding fan-shaped sections.

The analysis by Walden, with reduction by Clarke, is as follows:

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No. 652

ROUND SCREEN

(*Yuan Ch'a P'ing*)

Ch'ien-lung (1736–95)

Nephrite

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		$AlNaSi_2O_6$	$FeNaSi_2O_6$	Nephrite	Abstract	
Silica, SiO_2	57.89	4.68	2.04	51.17		
Alumina, Al_2O_3 . . .	1.99	1.99			Nephrite,	86.70
Ferric oxide, Fe_2O_3 . .	1.36		1.36		$AlNaSi_2O_6$,	7.88
Magnesia, MgO . . .	20.74			20.74	$FeNaSi_2O_6$,	3.93
Lime, CaO	12.60			12.60	Excess water,	1.51
Soda, Na_2O	2.06	1.21	.53	.32		
Water, H_2O	3.38			1.87		100.02
	100.02	7.88	3.93	86.70		

Number 182. *Hatchet* from the lake-dwellings of Neuchâtel, Switzerland. Specific gravity, 3.0118; hardness, 6.5; material very compact and subtranslucent. *Color*, olive-green.

Microstructure: Parallel fibres, sometimes in a slightly curved arrangement with a parallel or laminated structure strongly marked, and accompanied by crooked cracks. There is every appearance of the rock having been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism.

The analysis by Walden, with reduction by Penfield, is as follows:

		Glaucophane and riebeckite	Nephrite $RSiO_3$	Unaccounted for	Nephrite recalculated	Theory
Silica, SiO_2	57.19	7.44	49.75		57.35	57.69
Alumina, Al_2O_3 . . .	2.24	2.24				
Ferric oxide, Fe_2O_3 . .	1.60	1.60				
Ferrous oxide, FeO .	1.10		1.10			
Magnesia, MgO . . .	21.97		21.97		28.32	28.85
Lime, CaO	13.16	.73	12.43		14.33	13.46
Soda, Na_2O	.20	.20				
Potash, K_2O	1.44	1.44				
Water, H_2O	1.82		.90	.92		
	100.72	13.65	86.15	.92	100.00	100.00

The prevailing alkali is here potash, and it has been necessary to take some calcium to make up for the deficiency of the combined alkalis.

Number 120. *Slab* from boulder, Siberia. Specific gravity, 3.0070; hardness, 6.5; highly translucent, very compact and homogeneous, with characteristic splintery fracture. *Color*, seaweed-green clouded and stained with brown.

Microstructure: A nearly uniform mixture of amphibole fibres in fan-shaped, divergent clusters sometimes approaching a spherulitic arrangement.

The analysis by Walden, with reduction by Clarke, is as follows:

		$AlNaSi_2O_6$	R''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	55.96	1.97	2.43	51.56		
Alumina, Al_2O_3 . . .	2.33	.84	1.49		Nephrite,	85.86
Ferric oxide, Fe_2O_3 .	4.28		4.12		$AlNaSi_2O_6$,	3.32
Magnesia, MgO . . .	20.35			20.35	R''_2CaSiO_6,	10.30
Lime, CaO	13.49		2.26	11.23	Excess Fe_2O_3,	.16
Soda, Na_2O	.51	.51				
Water, H_2O	2.72			2.72		99.64
	99.64	3.32	10.30	85.86		

Here, unless the iron oxide is in error, the hornblendic molecule R''_2CaSiO_6 seems to be necessary.

Number 449. *Sculptured rock-mass* from China. Specific gravity, 2.9549; hardness, 6.5; a very large piece of remarkably pure material. *Color*, light pearly-gray.

Microstructure: A microcrystalline to microcryptocrystalline aggregation of colorless fibres and flakes or scales, having a confused arrangement, which in places approaches a more definite grouping, in which the fibres lie in several directions. In each of these directions the fibres are approximately parallel and slightly curving, so that the streaks or bands of fibres extinguish the light simultaneously between crossed nicols. The polarizing colors of these minute fibres are grays of the first order. They grade into thicker and more compact crystals with higher interference colors. Throughout this mass are scattered fragmentary crystals of colorless jadeite, which is distinguished from the amphibole by its higher refraction. The double refraction is also higher. Its prismatic cleavage is also characteristic. A lamellar twinning is present and in places is curved and apparently the result of strain. The amphibole is compact in some cases and fibrous in others. The transition is into compact amphibole which frays out into curved fibres at the ends. It is evident that the fibrous amphibole composing this rock has been derived from colorless pyroxene or jadeite, remnants of which still exist in the rock.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	Fe(NaK)Si_2O_6	Nephrite	Abstract	
Silica, SiO_2	57.46	6.36	1.25	49.85		
Alumina, Al_2O_3 . . .	2.70	2.70			Nephrite,	85.87
Ferric oxide, Fe_2O_3 . .	.83		.83		Jadeite,	10.70
Magnesia, MgO . . .	20.87			20.87	Ægirite ?	2.49
Lime, CaO	12.49			12.49	Excess water,	1.43
Soda, Na_2O	1.79	1.64	.15			
Potash, K_2O	1.64		.26	1.38		100.49
Water, H_2O	2.71			1.28		
	100.49	10.70	2.49	85.87		

Nephrite = $Ca(H_2Mg)_3(SiO_3)_4$ approximately.

Number 648. *A small saucer-shaped dish* from China (one of a pair). Specific gravity, 2.9758; hardness, 6.5; of translucent, homogeneous, and very compact material, with a mottling throughout part of it of a trifle more opaque and slightly darker substance, probably nephrite, and an inclusion in one part of a most pronounced crystalline structure that may be a remnant of former jadeite. A few microscopic flakes of colorless mica are present. *Color*, sage-green.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	$NaFeSi_2O_6$	Nephrite	Abstract	
Silica, SiO_2	57.42	5.49	1.96	49.97		
Alumina, Al_2O_3 . . .	2.66	2.35		.31	Nephrite,	85.51
Ferric oxide, Fe_2O_3 .	1.31		1.31		$NaAlSi_2O_6$,	9.26
Ferrous oxide, FeO .	1.78			1.78	$NaFeSi_2O_6$,	3.78
Manganous oxide, MnO	.28			.28	Excess water,	1.01
Magnesia, MgO . . .	14.30			14.30		
Lime, CaO	16.19			16.19		99.56
Soda, Na_2O	1.93	1.42	.51			
Water, H_2O	3.69			2.68		
	99.56	9.26	3.78	85.51		

The nephrite is distinctly hydrous, and the excess of lime over magnesia in it indicates its pyroxenic origin.

Number 162. *Boulder fragment* from New Zealand. Specific gravity, 3.0122; hardness, 6.5; translucent, very compact and homogeneous, admitting of a high polish; with transverse fracturing and laminæ parallel to the flat length of the mass. *Color*, rich dark green.

Microstructure: Fibres parallel, sometimes in curved arrangement with a parallel or laminated structure strongly marked and accompanied by crooked cracks. The rock appears to have been crushed or dragged, and the structure indicates a high degree of dynamic metamorphism.

The analysis by Walden, with reduction by Penfield, is as follows:

		Glaucophane $Na_2Al_2(SiO_3)_4$	Riebeckite $Na_2Fe_2(SiO_3)_4$	Nephrite $RSiO_3$	Nephrite calculated to 100%	Theory
Silica, SiO_2	57.78	5.52	2.40	49.86	57.52	57.69
Alumina, Al_2O_3 . . .	2.35	2.35				
Ferric oxide, Fe_2O_3 . .	1.60		1.60			
Ferrous oxide, FeO .	2.83			2.83		
Magnesia, MgO . . .	14.80			14.80	25.15	28.85
Lime, CaO	15.02			15.02	17.33	13.46
Soda, Na_2O	1.63	1.01	.62			
Potash, K_2O	1.00	.66				
Water, H_2O	2.75			2.45		
	99.76	9.54	4.62	84.96	100.00	100.00
Unaccounted for: Potash, 0.34; water 0.30 = 0.64.						

Number 299. *Fragment* of boulder from New Zealand. Specific gravity, 3.0000; hardness, 6.5; translucent, compact, and homogeneous. The tough, splintery character of the material is very apparent in many places. A number of the original boulder surfaces are still unworked. *Color*, spinach-green with patches of olive-green.

Microstructure: The amphibole fibres are in a confused aggregation, with occasionally longer streaks of nearly parallel fibres.

The analysis by Walden, with reduction by Clarke, is as follows:

		$NaAlSi_2O_6$	$NaFeSi_2O_6$	Nephrite	Abstract	
Silica, SiO_2	56.41	2.14	5.76	48.51		
Alumina, Al_2O_3 . . .	.91	.91			Nephrite,	84.23
Ferric oxide, Fe_2O_3 . .	3.84		3.84		$NaAlSi_2O_6$,	3.60
Ferrous oxide, FeO .	1.92			1.92	$NaFeSi_2O_6$,	11.09
Manganous oxide, MnO	.15			.15	Excess water,	1.41
Magnesia, MgO . . .	19.09			19.09		
Lime, CaO	12.81			12.81		100.33
Soda, Na_2O	2.64	.55	1.49	.60		
Water, H_2O	2.56			1.15		
	100.33	3.60	11.09	84.23		

Number 159. *Slab* said to be from New Zealand. Specific gravity, 3.0019; hardness, 6.5; translucent, homogeneous, and compact in structure; filled with splintery veinings and fractures. *Color*, light green.

Microstructure: Fibres parallel, sometimes in curved arrangement, with a strongly marked parallel or laminated structure. The rock gives evidence of having been crushed or dragged, and the structure indicates a very high degree of dynamic metamorphism.

The analysis by Walden, calculated by Clarke, is as follows:

		$Al(NaK)Si_2O_6$	$R'''_2(SiO_3)_3$	Nephrite	Abstract	
Silica, SiO_2	56.63	2.49	6.40	47.74		
Alumina, Al_2O_3 . . .	2.14	1.06	1.08		Nephrite,	83.10
Ferric oxide, Fe_2O_3 . .	3.99		3.99		$R'''_2(SiO_3)_3$,	11.47
Magnesia, MgO . . .	21.69			21.69	$AlR'Si_2O_6$,	4.44
Lime, CaO	13.41			13.41	Excess water,	1.41
Soda, Na_2O	.20	.20				
Potash, K_2O	.69	.69				100.42
Water, H_2O	1.67			.26		
	100.42	4.44	11.47	83.10		
K is equivalent to Na, and is put in the glaucophane-like molecule. State of iron doubtful.						

Number 351. *Wine-jug* from China; specific gravity, 2.9243; hardness, 6.5. *Color*, light gray, changed in part by oxidation to a darker gray, with brownish hues and seams and fractures of dead-oak-leaf color.

Microstructure: A microcrystalline to microcryptocrystalline aggregation of fibres of colorless amphibole that extinguish light between crossed nicols in irregular patches, some of which are banded in parallel lines. These patches correspond to the originally twinned pyroxene. In places the amphibole is in compact crystals. There is also a mottling similar to that noticed in the large crystals of jadeite, where it was the result of strain.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite, etc.	Nephrite	Abstract	
Silica, SiO_2	56.91	9.17	47.74	Nephrite,	81.61
Alumina, Al_2O_3 . . .	2.84	2.84		$R''R'Si_2O_6$,	16.36
Ferric oxide, Fe_2O_3 . .	1.56	1.56		Excess water,	2.58
Magnesia, MgO . . .	21.82		21.82	K_2O unaccounted for,	.02
Lime, CaO	11.56		11.56		100.57
Soda, Na_2O	1.62	1.62			
Potash, K_2O	1.19	1.17			
Water, H_2O	3.07		.49		
	100.57	16.36	81.61		

The pyroxene molecule here represents jadeite, $NaAlSi_2O_6$, and ægirite, $NaFeSi_2O_6$, with potassium partly replacing sodium.

Number 104. *Fragment* of boulder from Siberia. Specific gravity, 3.0138; hardness, 6.5; part of the original surface of what was a water-worn boulder. Translucent, showing on cut surface a remarkably homogeneous and compact texture. On the fractured surfaces very splintery, in some parts almost fibrous. A few included crystals of a black metallic substance, apparently chromic iron. *Color*, seaweed-green.

Microstructure: There are mottled patches, but the mottling is so coarse that the details of it can be seen. It consists of fan-like bundles of fibres crossing one another in two or more directions, sometimes producing spherulitic aggregates with four long arms. In other places the fibres are arranged in lines of lenticular or spindle-shaped bundles which produce curving lines. Between the latter are fibres in other orientations, probably bundles seen in cross-section. This appears to be the same structure that produces the mottling in the finer-grained forms. The long streaks of parallel fibres are very marked.

The analysis by Walden, with reduction by Penfield, is as follows:

		Glaucophane $Na_2Al_2(SiO_3)_4$	Riebeckite $Na_2Fe_2(SiO_3)_4$	Nephrite $RSiO_3$	Nephrite calculated to 100%	Theory
Silica, SiO_2	57.65	2.40	7.44	47.81	56.76	57.69
Alumina, Al_2O_3 . . .	1.06	1.06				
Ferric oxide, Fe_2O_3 . .	4.93		4.93			
Ferrous oxide, FeO .	.11			.11		
Magnesia, MgO . . .	14.95			14.95	24.19	28.85
Lime, CaO	16.05			16.05	19.05	13.46
Soda, Na_2O	2.38	.62	1.76			
Potash, K_2O	.93		.28			
Water, H_2O	2.46			2.42		
	100.52	4.08	14.41	81.34	100.00	100.00

Unaccounted for: Potash 0.65; water 0.04 = 0.69.

Number 96. *Boulder* from China (? Turkistan). Specific gravity, 2.9690; hardness, 6.5; the exterior worn down by attrition, and stained black and brown, though the inner surface is practically unaltered. *Color*, sage-green.

Microstructure: The once coarse-grained aggregate of pyroxene crystals is perfectly mapped out by patches of similarly oriented amphibole fibres arranged in a direction corresponding to the twinned positions of the pyroxene lamellæ, with patches of mottling so coarse that the details of the structure can be seen. It con-

No. 689

LARGE FISH-BOWL

(*Ta Yü Kang*)

Ch'ien-lung (1736–95)

Nephrite

sists of fan-like bundles of fibres crossing one another in two or more directions, sometimes producing spherulitic aggregates with four long arms. In other places the fibres are arranged in lines of lenticular or spindle-shaped bundles which produce curving lines. Between the latter are fibres in other orientations, probably bundles seen in cross-section. This appears to be the same structure that produces the mottling in the finer-grained forms.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite	Ægirite	Nephrite	Abstract	
Silica, SiO_2	57.43	7.39	2.82	47.22		
Alumina, Al_2O_3 . . .	3.14	3.14			Nephrite,	80.90
Ferric oxide, Fe_2O_3 . .	1.88		1.88		Jadeite,	12.44
Ferrous oxide, FeO .	.47			.47	Ægirite,	5.43
Magnesia, MgO . . .	19.68			19.68	Excess water,	1.35
Lime, CaO	12.04			12.04		
Soda, Na_2O	2.87	1.91	.73	.23		100.12
Water, H_2O	2.61			1.26		
	100.12	12.44	5.43	80.90		

Number 630. Small *round dish* from China. Specific gravity, 2.9564; hardness, 6.5; of translucent, homogeneous, and compact material, in which is seen a fine camphor-like, apparently crystalline structure that may possibly be due to traces of the former jadeite; and the *microscopic examination* bears out this observation. The coarse-grained aggregate of pyroxene crystals is perfectly mapped out by patches of similarly oriented amphibole fibres, arranged in a direction corresponding to the twinned positions of the pyroxene lamellæ. *Color*, white with light creamy tint.

The analysis by Walden, with reduction by Clarke, gave the following:

		$NaAlSi_2O_6$	Al_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	56.83	8.71	1.11	47.01		
Alumina, Al_2O_3 . . .	5.33	3.70	1.63		Nephrite,	79.97
Ferric oxide, Fe_2O_3 . .	.46		.46		$NaAlSi_2O_6$,	14.66
Magnesia, MgO . . .	19.38			19.38	Al_2CaSiO_6,	4.23
Lime, CaO	13.11		1.03	12.08	Excess water,	1.94
Soda, Na_2O	2.25	2.25				
Water, H_2O	3.44			1.50		100.80
	100.80	14.66	4.23	79.97		

Number 71. *Fragment* of boulder from Turkistan. Specific gravity, 3.0033; hardness, 6.5. *Color*, sea-weed-green.

Microstructure: A mixture of amphibole fibres in fan-shaped, divergent clusters sometimes approaching a spherulitic arrangement, as in No. 289. Some of the bundles, however, are longer and larger, and needles of compact amphibole are sparingly present.

The analysis by Walden, with reduction by Clarke, is as follows:

		$AlNaSi_2O_6$	$FeNaSi_2O_6$	Nephrite	Abstract	
Silica, SiO_2	58.04	5.24	6.96	45.84		
Alumina, Al_2O_3 . . .	2.23	2.23			Nephrite,	78.14
Ferric oxide, Fe_2O_3 . .	4.64		4.64		$FeNaSi_2O_6$,	13.40
Ferrous oxide, FeO . .	.16			.16	$AlNaSi_2O_6$,	8.82
Manganous oxide, MnO	.38			.38	Excess water,	.32
Magnesia, MgO . . .	14.50			14.50		
Lime, CaO	12.68			12.68		100.68
Soda, Na_2O	4.83	1.35	1.80	1.68		
Potash, K_2O	.39			.39		
Water, H_2O	2.83			2.51		
	100.68	8.82	13.40	78.14		

The nephrite contains water and alkalis, replacing magnesia. The iron determination may be doubtful.

Number 99. *Fragment* of worked nephrite from China. Specific gravity, 2.9680; hardness, 6.5; translucent, compact, splintery structure with veinings of darker material, and inclusions of some other dark, almost black mineral. *Color*, dark olive-green with russet veinings.

Microstructure: A confused aggregation of amphibole fibres, with occasional longer streaks of nearly parallel fibres and a faint suggestion of patches derived from pyroxene. The texture varies from place to place. Some of it is extremely fine-grained; in other places it is in patches of coarser grain.

The analysis by Walden, with reduction by Clarke, is as follows:

		$R''R'Si_2O_6$	R''_2CaSiO_6	Nephrite	Abstract	
Silica, SiO_2	56.13	9.46	1.40	45.27		
Alumina, Al_2O_3 . . .	5.06	4.02	1.04		Nephrite,	77.34
Ferric oxide, Fe_2O_3 . .	2.12		2.12		$R''R'Si_2O_6$,	16.57
Ferrous oxide, FeO .	1.01			1.01	R''_2CaSiO_6,	5.87
Magnesia, MgO . . .	19.20			19.20	Excess water,	1.00
Lime, CaO	11.88		1.31	10.57		
Soda, Na_2O	1.19	1.19				100.78
Potash, K_2O	1.90	1.90				
Water, H_2O	2.29			1.29		
	100.78	16.57	5.87	77.34		

Number 289. *Axe* from New Caledonia. Specific gravity, 2.9311; hardness, 6.5; polished all over except in two places where the weathered surface of the original boulder is visible. *Color*, brown of various shades.

Microstructure: A nearly uniform mixture of amphibole fibres, in fan-shaped, divergent clusters sometimes approaching a spherulitic arrangement.

The analysis by Walden, with reduction by Clarke, is as follows:

		$AlNaSi_2O_6$	$FeR'Si_2O_6$	Serpentine	Nephrite	Unaccounted for	Abstract	
Silica, SiO_2	52.60	3.40	1.62	4.92	42.66			
Alumina, Al_2O_3 . . .	1.45	1.45					Nephrite,	75.76
Ferric oxide, Fe_2O_3 . .	2.10		1.08			1.02	Serpentine,	11.32
Ferrous oxide, FeO .	2.14				2.14		$AlNaSi_2O_6$,	5.73
Manganous oxide, MnO	.10				.10		$FeR'Si_2O_6$,	3.32
Magnesia, MgO . . .	23.06			4.92	18.14		Unaccounted for,	3.16
Lime, CaO	12.72				12.72			
Soda, Na_2O	.93	.88	.05					99.29
Potash, K_2O	.57		.57					
Water, H_2O	3.62			1.48		2.14		
	99.29	5.73	3.32	11.32	75.76	3.16		

Silica in nephrite 0.05 per centum too low.

Number 322. Large flat *carved celt* from China. Specific gravity, 2.9506; hardness, 6.5; a confused aggregate of amphibole fibres, with a small amount of colorless jadeite in fan-shaped aggregates. *Color*, light gray and brown of various shades.

The analysis by Walden, with reduction by Clarke, is as follows:

		Jadeite?	Serpentine?	Nephrite	Unaccounted for	Abstract	
Silica, SiO_2	52.98	4.25	9.48	39.25			
Alumina, Al_2O_3 . . .	1.79	1.79				Nephrite,	69.87
Ferric oxide, Fe_2O_3 . .	.05				.05	Serpentine?	21.80
Ferrous oxide, FeO . .	.46			.46		Jadeite?	7.15
Manganous oxide, MnO	.05			.05		Unaccounted for,	.71
Magnesia, MgO . . .	25.49		9.48	16.01			99.53
Lime, CaO	13.39			13.39			
Soda, Na_2O	1.11	1.11					
Potash, K_2O	.71			.71			
Water, H_2O	3.50		2.84		.66		
	99.53	7.15	21.80	69.87	.71		

Number 130. *Section of rough mass* from Siberia. Specific gravity, 2.9758; hardness, 6.5; characteristic splintery structure of nephrite. *Color*, dark olive-green with a patch of very light green and irregular veinings of almost black.

Microstructure: Two thin sections studied showed slightly different characters. One Iddings found to be a fine felt of amphibole flakes with coarser fan-like aggregations of a micaceous mineral having the optical properties of a colorless chlorite, probably a variety of clinochlore like that found in the Jordansmühl specimen No. 134. The other micro-section does not exhibit any of the chloritic mineral but is a fine felt of amphibole with bundles of larger amphibole blades and crystals.

Clarke's calculation of Foote's analysis given below shows the presence in the specimen of nearly twenty-four per centum of clinochlore.

		(NaK)$AlSi_2O_6$	Clinochlore	Nephrite $R''SiO_3$	Unaccounted for	Abstract	
Silica, SiO_2	49.55	.70	8.64	39.28	.93		
Alumina, Al_2O_3 . . .	5.20	.30	4.90				
Chromic oxide, Cr_2O_3 .	.24				.24	Nephrite,	70.61
Ferric oxide, Fe_2O_3 . .	.78				.78	Clinochlore,	23.82
Ferrous oxide, FeO .	4.44			4.44		$R'AlSi_2O_6$,	1.20
Manganous oxide, MnO	.07			.07		Unaccounted for,	4.03
Nickel protoxide, NiO .	.18			.18			99.66
Lime, CaO	9.54			9.54			
Magnesia, MgO . . .	24.78		7.68	17.10			
Potash, K_2O	.05	.05					
Soda, Na_2O	.15	.15					
Water at 100° . . .	.28				.28		
Water at 180° . . .	.19				.19		
Water over 180° . .	4.21		2.60		1.61		
	99.66	1.20	23.82	70.61	4.03		

The reduction very uncertain; bases too high for the silica in nephrite. Alteration products other than clinochlore may be present.

Number 141. *Fragment* of crude jade from Jordansmühl, Silesia. Specific gravity, 2.9451; hardness, 6.5; translucent, very compact, tough splintery texture, breaking into irregular horn-like fractures. *Color*, spinach-green veined with black.

Microstructure: Numerous compact prisms of amphibole which grade into fibres, are in nearly parallel groups, and cross one another in several directions.

The analysis by Walden, with reduction by Clarke, is as follows:

		$AlNaSi_2O_6$	$FeNaSi_2O_6$	Nephrite	Unaccounted for	Abstract	
Silica, SiO_2	54.44	13.93	4.82	35.69			
Alumina, Al_2O_3 . . .	5.92	5.92				Nephrite,	62.81
Ferric oxide, Fe_2O_3 . .	3.72		3.15		.57	$FeNaSi_2O_6$,	9.29
Ferrous oxide, FeO . .	2.56			2.56		$AlNaSi_2O_6$,	23.45
Manganous oxide, MnO	.22			.22		Unaccounted for,	4.65
Magnesia, MgO . . .	16.79			16.79			100.20
Lime, CaO	7.51			7.51			
Soda, Na_2O	4.64	3.60	1.04				
Potash, K_2O	.28		.28				
Water, H_2O	4.12			.04	4.08		
	100.20	23.45	9.29	62.81	4.65		

Al and Fe probably in glaucophane and riebeckite molecules respectively.

Number 172. *Hatchet* from the lake-dwellings at Neuchâtel, Switzerland. Specific gravity, 3.0919; hardness, 6.5; the material exhibits a twinned horny structure. *Color*, very dark green, almost black.

Microstructure: Consists mainly of amphibole in minute, irregularly shaped crystals and some larger ones that exhibit distinct green color, with pleochroism from yellowish- to bluish-green. In places the amphibole

occurs in distinct prismatic crystals, with the prism faces and cleavage well developed. Between these minute crystals is a colorless mineral with lower refraction and low double refraction, of very pure substance, suggesting quartz. It is wholly allotriomorphic and interstitial, acting as a cement for the other minerals. Though in very small areas, it is widely scattered through the rocks and is present in considerable quantity for an accessory mineral. Distributed through the rock in much greater quantity are small particles of an almost colorless mineral whose form and optical properties correspond to those of clinozoisite. It constitutes about forty per centum of the rock. With it is associated a small amount of epidote, distinguished by its yellow color in thin sections. There are a few small crystals of colorless garnet, and small, irregularly shaped grains of a highly refracting yellowish mineral, possibly titanite, with attached grains of magnetite.

The analysis by Walden, with reduction by Penfield, is as follows:

		Glaucophane			Epidote	Quartz
		$NaAl(SiO_3)_2$	$NaFe(SiO_3)_2$	$(MgCa)SiO_3$	$HCa_2Al_3Si_3O_{13}$	
Silica, SiO_2	51.33	11.76	12.00	7.92	15.48	4.17
Alumina, Al_2O_3	18.31	5.00			13.31	
Ferric oxide, Fe_2O_3 . .	8.08		8.08			
Magnesia, MgO	4.05			4.05		
Lime, CaO	11.34			1.71	9.63	
Soda, Na_2O	5.76	2.66	3.10			
Potash, K_2O	.55	.55				
Water, H_2O	.76				.76	
	100.18	19.97	23.18	13.68	39.18	4.17

ABSTRACT OF THE REDUCTIONS

Number 41 (China), Calculated by Clarke.

Jadeite,	97.27	
Pseudo-jadeite,	.55	
Unaccounted for,	2.00	
	99.82	

Number 32 (Burma), Calculated by Clarke.

Jadeite,	95.81	
Pyroxene,	1.85	
Uncertain,	2.20	
	99.86	

Number 51 (Tibet), Calculated by Clarke.

Normal jadeite,	95.71	98.85
Pseudo "	3.14	
Unaccounted for,	1.32	
	100.17	

Number 42 (China), Calculated by Clarke.

Normal jadeite,	92.42	97.47
Pseudo "	5.05	
Unaccounted for,	2.27	
	99.74	

Number 362 (China), Calculated by Clarke.

Normal jadeite,	91.62	99.51
Pseudo "	7.89	
Unaccounted for,	.73	
	100.24	

Number 7 (Burma), Calculated by Clarke.

Jadeite,	86.27
Albite,	4.73
Anorthite,	.55
Al_2CaSiO_6,	1.72
$R''SiO_3$,	5.99
Unaccounted for,	.90
	100.16

Number 16 (Burma), Calculated by Penfield.

Jadeite,	85.59
Diopside,	13.90
	99.49

Water not accounted for.

Number 490 (China), Calculated by Clarke.

Normal jadeite,	84.29	94.36
Pseudo "	10.07	
Unaccounted for,	6.06	
	100.42	

Number 496 (China), Calculated by Clarke.

Normal jadeite,	81.61	98.79
Pseudo "	17.18	
Unaccounted for,	1.47	
	100.26	

Number 485 (China), Calculated by Clarke.

Normal jadeite,	79.24	99.24
Pseudo "	20.00	
Unaccounted for,	1.23	
	100.47	

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No. 380

LARGE DISH

(*Hsi-tzŭ*)

Ming Dynasty (1368–1644)

Nephrite

ABSTRACT OF THE REDUCTIONS (*Continued*)

Number 219 (Mexico),	Calculated by Penfield.	
	Jadeite,	77.86
	Ægirite,	12.95
	Diopside,	9.30
	Loss, water,	.48
		100.59
Number 177 (Switzerland),	Calculated by Clarke.	
	Jadeite,	75.61
	Fe'''_2CaSiO_6,	4.82
	Magnetite?	1.36?
	Nephrite,	16.81
	Unaccounted for,	1.62
		100.22
Number 4 (Burma),	Calculated by Penfield.	
	Jadeite,	70.38
	Analcite,	27.85
	Diopside,	2.69
		100.92
Number 18 (Burma),	Calculated by Clarke.	
	Amphibole ($Na_2Mg_7Si_8O_{24}$),	38.79
	Jadeite,	55.68
	Ægirite,	3.99
	Excess water,	1.45
		99.91
Number 303 (Mexico),	Calculated by Penfield.	
	Jadeite,	48.89
	Albite,	47.39
	Nephrite,	3.81
	Excess water,	.36
		100.45
Number 317 (China),	Calculated by Clarke.	
	Nephrite, approximately,	96.00
	Jadeite, "	4.00
		100.00
Number 79 (Turkistan),	Calculated by Clarke.	
	Nephrite,	95.83
	$R'AlSi_2O_6$,	1.59
	R'''_2CaSiO_6,	1.57
	Excess water,	.95
		99.94
Number 153 (Alaska),	Calculated by Clarke.	
	Nephrite,	95.58
	$NaAlSi_2O_6$,	1.36
	R'''_2CaSiO_6,	1.79
	Excess water,	1.49
		100.22
Number 78 (Turkistan),	Calculated by Clarke.	
	Nephrite,	95.32
	R'''_2CaSiO_6,	2.11
	Chromite,	.22
	$R'AlSi_2O_6$,	1.29
	Excess water,	.92
		99.86
Number 155 (Alaska),	Calculated by Clarke.	
	Nephrite,	95.57
	$NaAlSi_2O_6$,	1.43
	R'''_2CaSiO_6,	2.50
	Excess water,	1.01
		100.51

Number 234 (British Columbia),	Calculated by Clarke.	
	Nephrite,	95.05
	$NaAlSi_2O_6$,	.92
	Al_2CaSiO_6,	3.81
	Excess water,	.75
		100.53
Number 330 (China),	Calculated by Clarke.	
	Nephrite,	94.33
	Jadeite?	4.15
	Excess water,	2.05
		100.53
Number 83 (China),	Calculated by Clarke.	
	Nephrite,	92.83
	$NaAlSi_2O_6$,	2.15
	R'''_2CaSiO_6,	3.57
	Excess water,	1.72
		100.27
Number 458 (China),	Calculated by Clarke.	
	Nephrite,	92.72
	Serpentine,	1.93
	R'''_2CaSiO_6,	2.40
	Excess water,	3.23
		100.28
Number 134*a* (Silesia),	Calculated by Clarke.	
	Amphibole,	92.21
	R'''_2CaSiO_6,	6.44
	Unaccounted for,	1.80
		100.45
Number 134*b* (Silesia),	Calculated by Clarke.	
	Amphibole,	79.58
	R'''_2CaSiO_6,	18.41
	Unaccounted for,	2.40
		100.39
Number 134*c* (Silesia),	Calculated by Clarke.	
	$R'R'''Si_2O_6$,	5.74
	Nephrite,	93.01
	Water in excess,	1.07
		99.82
Number 618 (China),	Calculated by Clarke.	
	Nephrite,	92.48
	Jadeite?	5.77
	Ægirite?	1.62
	Excess water,	.56
		100.43
Number 180 (Switzerland),	Calculated by Clarke.	
	Nephrite,	92.09
	$R'''NaSi_2O_6$,	5.91
	Excess water,	2.68
		100.68
Number 81 (China),	Calculated by Clarke.	
	Nephrite,	91.21
	R'''_2CaSiO_6,	9.53
	Excess Fe_2O_3,	.33
		101.07

ABSTRACT OF THE REDUCTIONS (*Continued*)

Number 67 (Turkistan), Calculated by Clarke.	
Nephrite,	91.65
R'''_2CaSiO_6,	1.86
$(NaK)AlSi_2O_6$,	3.47
Excess water,	2.82
	99.80

Number 160 (New Zealand), Calculated by Clarke.	
Nephrite,	89.52
$AlNaSi_2O_6$,	2.35
$R'''_2(SiO_3)_3$,	8.28
Excess water,	.39
	100.54

Number 183 (Switzerland), Calculated by Clarke.	
Nephrite,	90.64
$NaFeSi_2O_6$,	3.58
$R'''_2(SiO_3)_3$,	2.48
Unaccounted for,	4.19
	100.89

Number 765 (India), Calculated by Clarke.	
Nephrite,	89.78
$NaAlSi_2O_6$,	2.67
$R'''_2(SiO_3)_3$,	6.73
Excess water,	1.27
	100.45

Number 97 (China ?), Calculated by Clarke.	
Nephrite,	89.02
Jadeite,	7.36
$R'''_2(SiO_3)_3$,	3.41
	99.79

Number 581 (China), Calculated by Clarke.	
Nephrite,	88.20
Jadeite,	7.56
R'''_2CaSiO_6,	2.74
Excess water,	1.30
	99.80

Number 80 (China), Calculated by Clarke.	
Nephrite,	86.89
$R'''_2(SiO_3)_3$,	10.45
$NaAlSi_2O_6$,	2.02
Excess water,	1.51
	100.87

Number 443 (China), Calculated by Clarke.	
Nephrite,	86.70
$R''NaSi_2O_6$,	11.81
Excess water,	1.51
	100.02

Number 182 (Switzerland), Calculated by Penfield.	
Nephrite,	86.15
Glaucophane and riebeckite,	13.65
Unaccounted for,	.92
	100.72

Number 120 (Siberia), Calculated by Clarke.	
Nephrite,	85.86
$AlNaSi_2O_6$ (Glaucophane ?),	3.32
R'''_2CaSiO_6,	10.30
Excess Fe_2O_3,	.16
	99.64

Number 449 (China), Calculated by Clarke.	
Nephrite,	85.87
Jadeite,	10.70
Ægirite,	2.49
Excess water,	1.43
	100.49

Number 648 (China), Calculated by Clarke.	
Nephrite,	85.51
$NaAlSi_2O_6$,	9.26
$NaFeSi_2O_6$,	3.78
Excess water,	1.01
	99.56

Number 162 (New Zealand), Calculated by Penfield.	
Nephrite,	84.96
Riebeckite,	4.62
Glaucophane,	9.54
Unaccounted for,	.64
	99.76

Number 299 (New Zealand), Calculated by Clarke.	
Nephrite,	84.23
$R''NaSi_2O_6$,	14.69
Excess water,	1.41
	100.33

Number 159 (New Zealand), Calculated by Clarke.	
Nephrite,	83.10
$R'''_2(SiO_3)_3$,	11.47
$AlR'Si_2O_6$ (Glaucophane ?),	4.44
Excess water,	1.41
	100.42

Number 351 (China), Calculated by Clarke.	
Nephrite,	81.61
$R''R'Si_2O_6$,	16.36
Excess water,	2.58
Unaccounted for,	.02
	100.57

Number 104 (Siberia), Calculated by Penfield.	
Nephrite,	81.34
Riebeckite, $Na_2Fe_2Si_4O_{12}$,	14.41
Glaucophane, $Na_2Al_2Si_4O_{12}$,	4.08
Unaccounted for,	.69
	100.52

Number 96 (China), Calculated by Clarke.	
Nephrite,	80.90
Jadeite,	12.44
Ægirite,	5.43
Excess water,	1.35
	100.12

Number 630 (China), Calculated by Clarke.	
Nephrite,	79.97
$NaAlSi_2O_6$,	14.66
Al_2CaSiO_6,	4.23
Excess water,	1.94
	100.80

Number 71 (Turkistan), Calculated by Clarke.	
Nephrite,	78.14
$R''NaSi_2O_6$,	22.22
Excess water,	.32
	100.68

ABSTRACT OF THE REDUCTIONS (*Continued*)

Number 99	(China),	Calculated by Clarke.	
		Nephrite,	77.34
		$R'''R'Si_2O_6$,	16.57
		R'''_2CaSiO_6,	5.87
		Excess water,	1.00
			100.78
Number 289	(New Caledonia),	Calculated by Clarke.	
		Nephrite,	75.76
		Serpentine,	11.32
		$R'''(NaK)Si_2O_6$,	9.05
		Unaccounted for,	3.16
			99.29
Number 322	(China),	Calculated by Clarke.	
		Nephrite,	69.87
		Serpentine?	21.80
		Jadeite?	7.15
		Unaccounted for,	.71
			99.53
Number 130	(Siberia),	Calculated by Clarke.	
		Nephrite,	70.61
		Clinochlore,	23.82
		$R'AlSi_2O_6$,	1.20
		Unaccounted for,	4.03
			99.66
Number 141	(Silesia),	Calculated by Clarke.	
		Nephrite,	62.81
		$FeNaSi_2O_6$,	9.29
		$AlNaSi_2O_6$,	23.45
		Unaccounted for,	4.65
			100.20
Number 172	(Switzerland),	Calculated by Penfield.	
		$NaAl(SiO_3)_2$ } Glaucophane,	19.97
		$NaFe(SiO_3)_2$ } Glaucophane,	23.18
		$(MgCa)SiO_3$ } Glaucophane,	13.68
		Epidote, $HCa_2Al_3Si_3O_{13}$,	39.18
		Quartz,	4.17
			100.18

Professor Clarke remarks, in regard to these reductions, that the nephrite molecule always reduces to the general formula $R''SiO_3$, when $R'' = Ca$, Mg, Fe, or Mn. In typical nephrite it approximates to $CaSiO_3 + 3MgSiO_3$, or $CaMg_3(SiO_3)_4$; the Fe and Mn replacing a part of the Mg. H_2, K_2, and Na_2 may also replace Mg to some extent, but the Ca is more commonly constant. Variations occur in the reductions which may be due to error in the iron determinations; and in other cases traces of pyroxene remain, with the ratio more nearly Ca : Mg :: 1 : 1; as in diopside, $CaMg(SiO_3)_2$.

When Iddings states that jadeite or its equivalent is present in a nephrite, jadeite and ægirite are stated as such. When no definite statement is made, a formula is given which may indicate either jadeite, ægirite, glaucophane, or riebeckite molecules; and formulæ are stated as follows:

$AlNaSi_2O_6$
$FeNaSi_2O_6$
$Al(NaK)Si_2O_6$, or $AlR'Si_2O_6$
$Fe(NaK)Si_2O_6$, or $FeR'Si_2O_6$
$R'''NaSi_2O_6$
$R'''KSi_2O_6$, etc.

— according to the exigencies of the case. All of these are covered by the one general formula, $R'''R'Si_2O_6$, which is sometimes employed.

When alkalis are in excess of alumina and ferric oxide, they are treated as part of the nephrite molecule. When Al_2O_3 and Fe_2O_3 are in excess, two alternatives are presented. First, if the total oxygen of the analysis is greater than in the ratio SiO_3, it is treated as part of the molecule $(AlFe)_2CaSiO_6$, or R'''_2CaSiO_6, which is mentioned by Clarke in introducing the chemical section of this work. Secondly, when the silicon-oxygen ratio is normal—that is, 1 : 3—the excess of Al and Fe is regarded as forming the molecule $R'''_2(SiO_3)_3$, which might be considered as a replacement in the nephrite, and equivalent partly to babingtonite among the pyroxenes, and arfvedsonite among the amphiboles. In two or three cases the analyses indicate serpentine as an impurity, which is so stated.

In the jadeites Penfield has shown that Ca, Fe, or Mg may replace Na or K; and he computes analyses with small amounts of these elements included. Clarke divided the computation in such cases, giving *normal* jadeite as proportional to the alkalis alone. The remaining portion, $Al_2(CaMgFe)(SiO_3)_4$, the replacement which Penfield has proved, Clarke calls *pseudo*-jadeite. The sum of the normal jadeite and the pseudo-jadeite gives the jadeite of Penfield's calculations.

INCLUSIONS

Under this head it is proposed to notice briefly the various minerals which have been found in intimate association with jadeite or nephrite. They may be roughly grouped into two classes:

First. Those which occur in relatively small crystals or patches embedded in jade, and by reason of their sharply defined contrast in color or form are readily visible to the naked eye.

Second. Those which occur intimately intermingled with the jade, forming an essential part of its mass, and, being of the same color and appearance, are recognizable as foreign material only by chemical or microscopic study.

To the first of these may be assigned the following minerals: Chromite, magnetite, garnet, feldspar, pyrite, rutile, limonite, manganese oxide, mica, and several other undetermined impurities.

Chromite and magnetite are by far the most common impurities to be noted in jade. The distinction between them is not generally visible, since both occur in black opaque octahedrons, generally of minute size, and it is necessary, in order to their positive distinction, to prepare a thin microscopic section. The chromium may then be readily determined, as it is slightly translucent in thin sections and shows a dark-brown color in microscopic sections, whereas magnetite is always black and opaque. This class of inclusions is generally too small in percentage to produce any effect except, in some cases, a change of color of the mass. Again, if a dark crystalline speck is surrounded by a zone of green brighter than the rest of the specimen, it is safe to conclude that the coloring of the green is chromium derived from the inclusion, which is, therefore, undoubtedly chromite. Both these minerals are very noticeable in translucent jade, as their color is dark and their sharp form is readily distinguishable in a translucent mass. When the inclusions are present in a sufficient number in white jade, they frequently give it a grayish tint. In sufficient number they may even impart a positive black to the mass.

Pyrite, rutile, garnet, feldspar, and mica all occur as inclusions discernible by the naked eye.

Black oxide of manganese is frequently present in both the jade minerals, chiefly as a staining material, and sometimes in such quantity as to impart a positively black color. It also occurs in thin coatings on the walls of cracks or crevices, and again as dendritic markings.

Limonite appears in a number of specimens, perhaps more especially among the artistic pieces, as a staining, generally the result of weathering, and is considered by the Chinese to heighten the effect.

In addition to the inclusions already described, which are perceptible to the naked eye, a large number of minerals exist in minute crystals, and have been determined by microscopic study of jade itself. The following species have been determined by Arzruni, Iddings, and others as occurring in jade:

Andalusite,	Muscovite,	Rutile,
Cordierite,	Olivine,	Talc,
Epidote,	Perovskite with	Titanite,
Garnet,	Leucoxene,	Tourmaline,
Limonite,	Quartz,	Zircon.

In addition to these, Arzruni reports graphite as occurring in nephrite.

The second class of inclusions, in which the foreign mineral plays a more important part in the make-up of the mass, contains the following species: Analcite, albite, nepheline, plagioclase, feldspar, zoisite (clinozoisite), and diopside. All these are of peculiar interest from the fact that they are found with jadeite and not with nephrite. The only mineral reported as chemically intermixed with nephrite is doubtful serpentine.

The important part that such included minerals play in jade may be seen in four results: First. They affect the color of the mass in which they are included, giving it a tint, a mottled appearance, or in some instances a decided color. Second. They are likely to affect the specific gravity of the mass either by lowering it, as in the case of albite feldspar, or by raising it, as in the case of magnetite and chromite. Third. They are likely to affect the apparent chemical composition of the mass by their intimate mechanical mixture. Fourth. They may likewise, at times, affect the hardness of the mixture.

This class of inclusions may equal or exceed the amount of the jadeite material in the rock, with the changes that may be expected in the lowering of the hardness, toughness, or specific gravity, and in the case of nepheline and analcite rendering the mass more susceptible to the attack of weathering agencies.

The effect upon the physical and chemical character of jade produced by the presence of the inclusions above mentioned will depend, of course, upon the amount and character of the inclusions.

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No. 443

DOUBLE PHENIX VASE

(*Shuang Fêng P'ing*)

K'ang-hsi (1662–1722)

Nephrite

ON THE ORIGIN OF JADEITE

The very fact, so well known, that the original sources of jadeite have either been unknown or veiled in mystery, in spite of its use and commercial value through such an immense period of time, implies at the very outset that geological observations and knowledge concerning its mode of occurrence and the origin of the material must be still more defective. We know, indeed, that it has been largely gathered in the shape of transported boulders; and the study of the material has led petrographers to classify jade as belonging to the crystalline schists. Anything beyond this, with the exception to be presently noted, which is of any real value in this connection has not come to the writer's knowledge, and it would be of little interest or value to discuss the question from the historical side.

Occurrences in Burma and "Tibet"

The occurrence which has been best studied is that at Tammaw in Upper Burma. As this is described elsewhere in this volume, in the article on the Localities and Geological Occurrence of Jade, the reader must be referred to that section for details. It must here suffice to say that the observations of Noetling and Bauer show that the jadeite is either igneous or metamorphic in character, the results of the careful petrographical examination of Bauer favoring the latter view. The jadeite is associated with serpentine, and glaucophane schist and albitic rocks occur in the vicinity.

The jadeite said to come from Tibet, described by Bauer, has been incorporated also in the same section, and it need only be said here that, while it resembles in general that of Tammaw, it contains considerable nephelite and some albite. Bauer calls attention to the anomaly of the presence of nephelite as a component of a rock belonging to the crystalline schists, since heretofore it has been found only as a component of igneous rocks. The writer hopes to elucidate in the following pages the meaning of this apparent anomaly.[1]

It may also be mentioned that some specimens of jadeite in the Collection (Nos. 4, 219, 362, 497) contain small amounts of albite and analcite.

Jadeite Considered as a Rock

It is clearly evident, not only from the occurrence at Tammaw described elsewhere, but from its distribution in a number of localities and the size of the masses in which it is found, that jadeite must be considered as a rock, and a definite kind of rock, not some chance formation of a mineral on a considerable scale in a single locality by a peculiar combination of circumstances not liable to obtain elsewhere. It appears to be a well-characterized variety of rock produced by the same laws which govern the formation of other rocks of similar type, and one the number of whose occurrences may be expected to increase as the geological exploration of the world goes on. This position, it appears to the writer, is so self-evident that it needs no further argument; it is also the one generally assumed.

It may then fairly be asked if jadeite in itself, by its properties and structure, mineral and chemical composition, offers evidences which, interpreted by the aid of our present knowledge of petrology, are sufficient to indicate its origin and petrographic position. The writer believes that this question can be answered in the affirmative, and purposes to show the reasons for so believing.

Chemical Composition

The first, and perhaps the most important, question which can be asked is whether the chemical composition of jadeite as a rock, *en masse*, offers any evidence. If we consider jadeite, $NaAl(SiO_3)_2$, as a mineral alone, this requires in theory

SiO_2	59.4
Al_2O_3	25.2
Na_2O	15.4
	100.0

[1] Cf. American Journal of Science (4), 1896, Vol. I, p. 401.

As a matter of fact, however, jadeite, even in the whitest and simplest varieties, almost never has a pure composition, but contains in addition lime, iron, and magnesia, sometimes in considerable amounts, together with small quantities of potash and traces of water, as may be seen from the appended table of analyses, and from the tables given elsewhere in this volume.

Analyses of Jadeite and Phonolite

	I	II	III	IV	V	VI	496	41	4	7
SiO_2 . . .	57.99	58.51	60.52	53.80	58.98	53.95	58.48	57.60	58.41	58.58
Al_2O_3 . . .	20.61	19.66	19.05	23.59	20.54	21.96	23.57	25.75	24.64	23.71
Fe_2O_3 . . .	2.84	3.43	4.22	3.57	1.65	.76	1.68		.67	.51
FeO . . .				1.88	.48					.24
MgO . . .	3.33	.31	.19	.87	.11	7.17	1.33	.13	1.24	1.35
CaO . . .	4.89	1.53	.59	2.26	.67	2.42	1.62	.58	1.43	1.67
Na_2O . . .	9.42	10.04	10.63	9.05	9.95	9.37	10.33	13.31	12.76	13.80
K_2O . . .	1.50	4.71	3.50	4.77	5.31	3.70	3.09	2.20	.58	trace
H_2O . . .		1.00	.04	1.50	.97		.16	.25	1.19	.16

I—Worked jade from France, Damour, *Bull. Soc. Min.*, 1881, IV, 157.
II—Phonolite, Mte. Miaune, Velay, Emmons, *Inaug. Diss.*, Leipzig, 1874, p. 20.
III—Phonolite-obsidian, Teneriffe, Fritsch and Reiss, 1868, p. 337.
IV—Phonolite, St. Thiago, Cape Verde Is., Doelter, *Vulkane der Cap Verden*, 1882, p. 90.
V—Phonolite, Cripple Creek, Colo., W. F. Hillebrand, *U. S. G. S. Bull.*, 148, p. 161.
VI—Unworked jade, Burma, Damour, *loc. cit.*, 1881.
496—Analysis by Walden of worked jadeite from China.
41—Analysis by Walden of worked jadeite from China.
4—Analysis by Walden of fragment of boulder from Burma.
7—Analysis by Foote of fragment of boulder from Burma.

NOTE.—In these analyses only the important elements are given for comparison; the traces of various metals and bases are omitted as unimportant, and in consequence no summation is shown.

It is clear, from what has been quoted from Noetling's description, that at Tammaw the jadeite must be either a metamorphic rock, a member of the crystalline schists, or else it must be igneous. And this, of course, must be true of all jade if we consider it a rock, as its appearance and crystalline character at once exhibit.

If we regard it as a member of the crystalline schists, a metamorphic rock, we must still again, if possible, endeavor to account for its origin, for these rocks must be also of igneous or aqueous formation originally, unless some of them in places be excepted, as has been done by some geologists, because they are held to be a portion of the earth's original cooling crust. Now we know of no sediments, nor indeed any possible combination of sediments, which could occur that, having been metamorphosed, would give us jadeite. A possible mixture of salt, sand, and clay well mixed would have approximately the chemical composition, but where conditions were such that salt could deposit, sand certainly could not. It seems not unreasonable to say that the source of the material forming jadeite could not have been of aqueous deposition.

There remains, then, to consider whether the material may not have been of igneous origin; and when we compare analyses of jadeite with those of igneous rocks, we see at once that it has the composition of the nephelite-syenite group as shown by the comparison of analyses in the table given above. It will be seen that there is a striking agreement between the two groups of rocks, and that the analyses from one group might with ease pass muster in the other. There is one point of general difference, and that is the small amount of potash shown in the jade analyses. It is not wanting, however, and may exist in considerable quantity, as shown in Nos. 41 and 496, and in No. I. This is not any valid argument against the material being of igneous origin; for while potash and soda are usually found in considerable proportion relative to each other in igneous rocks, this is not necessarily so, and we have actual instances of undoubted igneous rocks, as in dikes and lava flows, showing so great an excess of one alkali as practically to exclude the other. Instances may be seen in the following examples:

	1	2	3	4	5	6	7	8
Na_2O	1.21	1.39	.90	3.37	7.62	4.21	5.34	17.29
K_2O	11.91	11.76	7.99	10.06	.10	.17	.18	3.51

The first three of these are leucitic lavas from the Leucite Hills in Wyoming; the fourth, a feldspathic dike from the Highwood Mountains of Montana; the fifth, an aplite dike from Mariposa, California; the sixth, diabase, Connecticut Valley, Massachusetts; the seventh, porphyritic amphibolite, New Salem, Massachusetts; and the eighth, urtite from Kola. (The first seven from Bulletin 148, United States Geological Survey; the eighth, from Ramsay, "Geol. Fore. Stockholm Forh," 1896, Bd. XVIII, p. 462.) They have been selected as examples, and numbers of others equally striking might be given in addition, but these are sufficient to show the point involved. The composition of jadeite is precisely that of a phonolite in which the potash is very low or lacking.[1] The analyses vary one from another in a slight degree, but they all lie within the same limits.

That jadeite has the essential composition of a phonolite is shown most strikingly by the chemical equation:

$$NaAlSiO_4 + NaAlSi_3O_8 = 2NaAl(SiO_3)_2$$

$$\frac{\text{Nephelite} + \text{Albite}}{\text{Phonolite}} = \text{Jadeite.}$$

That is to say, a soda feldspar and nephelite, the chief constituents of a phonolite, if united would form jadeite. Clarke,[2] in discussing the structural formulæ of minerals of the pyroxene group like jadeite, calls attention to the fact that on alteration spodumene splits up into feldspar and eucryptite, the latter a lithia nephelite, while leucite, which has a similar empirical formula, divides into orthoclase and nephelite, soda replacing part of the alkali in both cases. From this Clarke argues that the real structural formula of spodumene is not that of a simple metasilicate, $RSiO_3[LiAl(SiO_3)_2]$, but $Al_6(Si_3O_8)_3(SiO_4)_3Li_6$, which expresses the relations mentioned above. Following out this line of reasoning, then, jadeite, also a member of the pyroxene group and closely related to spodumene, would not have the simple empirical formula $NaAl(SiO_3)_2$, but the complex one $Al_6(Si_3O_8)_3(SiO_4)_3Na_6$, and theoretically it is merely an addition product of the albite and nephelite. Such addition products might readily be formed if chemical action was taking place under great pressure such as is developed under dynamo-metamorphic processes, since in that case there is a tendency to form denser molecules of higher specific gravity; thus, one molecule of albite, specific gravity 2.62, and one molecule of nephelite, 2.60, could unite to form one molecule of jadeite, 3.33.

Associated Minerals and Structure

In this connection, the jadeite said to be from Tibet and described by Bauer is most significant. Here it is accompanied by nephelite and feldspar. Now nephelite is known, so far, to occur only as a product of the cooling of a molten magma in igneous rocks, and it is indeed difficult to imagine how the material of which it is composed could originate in any other way. Certainly not as a sediment. The occurrence of this mineral in the jadeite said to be from Tibet points most strongly toward the igneous origin of the material in which it occurs, and the presence of the feldspar would lend additional value to this idea.

Similar remarks and conclusions apply to those specimens of jadeite in the Collection in which, as has been mentioned, analcite occurs. This mineral, a hydrous metasilicate of soda and alumina, occurs commonly as a secondary product resulting from the alteration of minerals rich in soda in the igneous rocks, but it has also been shown recently to be a primary constituent of certain dike-forming igneous rocks. The mode of its occurrence, as described by Iddings, would indicate that it is here probably either a primary constituent, or that it is the result of the decomposition of nephelite or albite, indicating an igneous origin for the rock in either case. There is also a possibility that it is derived from the jadeite itself, though the description would seem to preclude this.

On the other hand, certain facts in this connection must also be considered. Jadeite, the mineral, from its chemical composition, is a pyroxene which *a priori* might be considered extremely likely to occur in alkaline igneous rocks rich in soda. As a matter of fact, not a single instance of this, so far as is known to

[1] Rosenbusch briefly remarks that jadeite has the composition of a nephelite-syenite magma. Elemente der Gesteinslehre, p. 508.

[2] Constitution of the Silicates, Bulletin United States Geological Survey, No. 125, p. 87.

the writer, has been recorded. Moreover, the broken, cataclastic structure of the mineral, and in fact the whole structure of the rock, so carefully described by Bauer, points most clearly to a type originating from metamorphic processes. The associated rocks found with the jadeite in the region in Upper Burma are an albite-hornblende-schist and a glaucophane-schist, both of them rocks rich in soda and metamorphic in type. Both facts are significant.

Summary and Conclusions

Briefly summarized, we have, then, the following facts to deal with. The evidence of the only place where jadeite has been well studied in place by a competent geologist does not afford a definite conclusion as to the origin of the rock; it may be igneous, or it may be metamorphic, the microscopic evidence tending to confirm the second conclusion. The composition of jadeite considered as a rock is that of an igneous one and a member of the nephelite-syenite group, characterized by the absence of potash or the small amount of it contained. In one occurrence nephelite is found in the jadeite, and in others analcite. The chemical composition of jadeite precludes the material from having an origin by aqueous deposition: it must be igneous. On the other hand, jadeite has not been found as a component of evidently unaltered igneous rocks, though the chemical composition of some of them might favor its formation; the structure of jadeite is that of the crystalline schists, and the rocks associated with it are members of that family. All these facts point to only one possible conclusion. Jadeite is a metamorphosed igneous rock, a member of the phonolite family. The whiter varieties are probably metamorphosed dikes of the aplitic, leucocratic type, belonging in this family, and the darker-green types those containing more iron-bearing dark silicates like the tinguaites.

And it may be suggested here that the non-appearance of rocks of the phonolite families as such among the crystalline schists may be brought into relation with the occurrence of jadeite, albite, and glaucophane schists and other types rich in alkalis, whose homes are in the metamorphic complexes.

THE RELATION OF JADEITE AND NEPHRITE

The origin of jadeite has already been discussed in the preceding section by Professor L. V. Pirsson, who shows that the available evidence is in favor of the view that jadeite is not an unaltered igneous rock, but that it is probably the result of the metamorphism of an original igneous rock of the nephelite-syenite-phonolite family. As the evidence is presented very fully by him, it is unnecessary here to do more than refer to his article, with the conclusions of which I agree in the main.

I need only add that the origin or formation of jadeite rocks will remain in doubt until they have been found in place in such a manner that their outward relations to the associated rocks may be discovered. For though they may be intimately associated with crystalline schists, and may exhibit schistosity in part, they may, however, have been originally igneous intrusions with the mineralogical composition of jadeite rocks, the structure of which has been subsequently somewhat modified by dynamic processes.

Whatever may have been the origin of jadeite rock, it has undergone since its formation various degrees of metamorphism, which has produced either slight modifications of the original texture of the rock or has altered it more or less completely both in texture and in chemical composition. By metamorphism is understood any alteration that may take place in a rock by which it may be changed into a coherent solid mass differing in some respect from the original rock. In many cases the resulting rock is harder and more crystalline than that from which it was formed, but this is not universally the case, and no simple definition of metamorphism can be framed unless we adhere to the etymology of the word and state that it is a change in the form of the rock.

The change may be limited to one of its characters or may affect several or all of them. It may operate in one direction or in a reverse one. Thus metamorphism may modify the form of the minerals without producing any chemical differences in them, as when a rock composed of a single kind of mineral has the crystals of the mineral reduced in size by crushing. They may by other metamorphic processes be enlarged. The first process would tend to make the rock less crystalline; the second, to make it more crystalline.

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No. 460

DOUBLE FISH-DRAGON VASE

(*Shuang Yü-lung P'ing*)

K'ang-hsi (1662–1722)

Nephrite

While it is possible for single or simple processes of metamorphism to affect a rock without the accompaniment of other processes, and while it may be desirable in the discussion of such actions to consider them separately, it seldom happens that in actual fact any one force or agency of alteration has acted independently of others. More often several have coöperated to produce the changes that have taken place.

In the case of the rocks grouped under the general term *jade*, which with few exceptions consist of jadeite or nephrite, the question of metamorphism has a special bearing on the origin of one of these component minerals,—namely, nephrite,—and must also be called into account to explain the texture exhibited by the jadeite rocks.

It is well known that the simple effect of dynamic forces tending to compress or distort a mass of crystals is to set up molecular stresses, which result in molecular strains within the individual crystals or which produce rupture and fragmentation. The latter shows itself under the microscope by the mingling of comparatively large crystals with small ones in such a manner as to indicate that the small particles are fragments of larger crystals. The small grains occur in streaks along cracks, or act as a cement or matrix for the larger grains. This is sometimes called cataclastic structure, and is to be seen in thin sections of Nos. 42, 43, 490, 496. Crushing may be accompanied by other alteration, as in the cases just mentioned. The minute particles are still jadeite, and the whole mass is a coherent rock held together by the adhesion of the component crystals. Similar metamorphism has been produced in the laboratory by Professor Adams of Montreal, by means of simple pressure.

The effects of molecular strains which may not have led to the production of visible fractures are shown by the optical behavior of the strained crystals when examined between crossed nicols. The results may be molecular displacement, producing a mottling of the interference color exhibited by a thin section of the crystal so affected. This may be more or less pronounced, varying from the faintest suggestion of mottling to one in which the mottling resembles mosaic work, with a distinct demarcation between each piece, where an actual fracturing of the crystals may have taken place.

In other cases the molecular displacement may cause the molecules to shift their position along certain planes in the crystal, producing layers or laminæ in twinned position with respect to the original crystal. In pyroxene one such plane is parallel to the basal pinacoid, and crystals of pyroxene subjected to this kind of molecular strain exhibit a more or less distinct banding of the interference color shown by thin sections when observed between crossed nicols. Examples of both of these kinds of molecularly strained jadeite may be seen in thin section of No. 43. The material is still jadeite, but the original adjustment of the crystal molecules has been altered. Such changes as those already illustrated by the jadeite sections may be called simple dynamic metamorphism.

It has been found that when crystals are in a state of molecular strain they are more susceptible to chemical and crystalline alteration, if agencies capable of promoting such changes are at hand. The same is true when the crystal is in fine particles which expose greater surface to attacking agencies, such as gases and liquids, than larger fragments do. It follows from this that rocks subjected to dynamic forces sufficient to produce metamorphism are the more easily altered by chemical processes, the commonest of which is the interaction of elements in adjacent crystals of dissimilar minerals, or of those in adjacent crystals and liquids which may penetrate the mass. These liquids may act as agents to promote the mobility of the molecules of adjoining crystals, by solution, or may be the vehicle by which elements may be transferred from one rock to another.

It frequently happens that rocks exhibiting dynamic metamorphism in the form of crushing and shearing or dragging also show chemical metamorphism, the chemical composition of the original rock being changed to a greater or less extent and a new crystallization taking place—that is, new minerals forming at the expense of those originally present.

Of the transformations of this kind commonly met with in rocks the change of pyroxene into amphibole is one of the most frequent. The close chemical and crystallographic relationship between these two groups of minerals may in part account for the frequency of this transformation. The probably greater complexity of the pyroxene molecule, to which Professor Clarke has called attention in another section of this work, may account for the fact that the alteration is usually from pyroxene to amphibole. In every such change there

is necessary a chemical displacement, for the elements do not occur in the same proportions in the two groups of minerals. The extent of this chemical metamorphism varies with attendant conditions, and may be considerable. In the case of some minerals the displacement has gone to the extent of replacing all the elements originally present by others totally unlike them. This is illustrated by paramorphs of the greatest variety.

The microscopical and chemical investigations of the specimens in this Collection demonstrate clearly that jadeite is commonly changed into aggregations of minute amphiboles—nephrite—subsequent to, or accompanying, dynamic metamorphism, and that the chemical change involved the displacement of aluminium and sodium by magnesium, calcium, and iron. Chemical metamorphism as radical as this may be found in the transformation of albite and orthoclase into talc or chlorite.

The evidences of dynamic and chemical metamorphism in the jades of this Collection have been described in detail in another place. They may be summarized briefly as follows: In some specimens of jadeite a cataclastic structure has been developed; in others, this structure together with mottlings of the interference colors and banding due to secondary lamellar twinning; in some jadeite specimens there are bladed crystals of amphibole; in specimens of nephrite there are fragments of jadeite; in some nephrites the amphibole crystals are arranged in patches corresponding to grains of jadeite in the jadeite specimens; this character gradually disappears in nephrite with more and more pronounced fibrous or laminated structure.

From these phenomena it may be concluded that jadeite is sometimes metamorphosed into nephrite; conversely, that nephrite is sometimes metamorphosed jadeite. But it does not necessarily follow that all nephrite is metamorphosed jadeite, or that the only product of the metamorphism of jadeite is nephrite. It may be added that so far as the Collection of jades studied is concerned no other changes have been observed. From which it may be concluded that this relationship between jadeite and nephrite is the normal one.

LOCALITIES AND GEOLOGICAL OCCURRENCE OF JADE

Discussion of the localities and occurrence of jade (including jadeite and nephrite) is of interest from two points of view. From the geological and mineralogical it is of great importance as furnishing us with facts which may elucidate the problem of the origin of the rock; from the archæological it is of equal importance as bearing on such questions as ancient lines of trade and intercommunication, and the spread of customs and migration of races.

We are met at the outset of such an investigation by the difficulty of lack of sufficient data. Although jade objects are wide-spread (within certain limits), and their number is very considerable, and though the use of this material goes back to the Stone Age, yet less than a dozen localities are known where the material occurs *in situ*, and a few more where it is found as rough blocks which have been transported from their original situations by river or glacial action. This state of affairs is somewhat remarkable in view of the peculiar qualities of jade—its toughness and composition, which offer great resistance to destruction by meteoric and other agencies, and its often striking coloration, which, one might expect, would lead to its easy discovery.

For our purposes it will be well to divide the occurrences into four groups, fundamentally distinct in character, which, in the order of their usefulness and importance, are as follows:

1. Occurrences of jade *in situ*.
2. Occurrences of jade as transported blocks.
3. Occurrences of jade as worked objects, generally of unknown exact ultimate provenance.
4. Localities mentioned by various authorities, but of very uncertain character.

In such a division we start with geological data which are fairly safe and well established, and by means of which the conditions of occurrence are more or less well known, through occurrences where the original conditions are to a large extent inferential, and finally end with groups where the origin is hypothetical and highly uncertain.

For the sake of convenience, in the following description, the first two groups will be treated together to a great extent, and also here the occurrences of jadeite and nephrite will be mentioned indiscriminately, though in the subsequent discussion the two will be sharply discriminated.

Burma

It seems appropriate to begin with this locality, since it is one of the greatest sources of the material, and is also one of those which have been the best studied. The quarries are found in Upper Burma, in the Kachin country, near the junction of the Chindwin and Uru rivers, in about latitude 25° north and longitude 95° east.

The quarries were discovered accidentally by a Yunnan trader in the thirteenth century, and several unsuccessful expeditions were sent out from Yunnan in that and the succeeding centuries. The attempts were abandoned till 1784, when a trade was opened between China and Burma, and a regular supply of the stone was carried into Yunnan. Since 1806 Mogaung has been the headquarters of the jade trade in Burma.

Apparently the first[1] notice of this locality by a European is that of Captain Hannay,[2] who obtained in Mogaung several pieces of a green mineral called by the Burmese "Kyouk-sein" and by the Chinese "Yueesh."[3] This was considered by Hannay to be "Nephrite."

The next European writer to mention the locality, and, according to Noetling, the first to visit it, was Dr. Griffith,[4] who considered the rock to be serpentine.

Captain Yule[5] speaks of the locality, but, according to Noetling, apparently bases his remarks on the observations of the two preceding writers.

The quarries are next described by Dr. J. Anderson,[6] but his account is short, and it does not appear that he himself visited the locality.

In 1888 Mr. W. Warry,[7] political officer at Bhamô, made an extensive report on the jade-mines of Mogaung. It deals chiefly with the history of the quarries, the methods of mining, and the question of revenue, but the following may be quoted:

"The jade-producing country is partly enclosed by the Chindwin and Uru rivers, and lies between the twenty-fifth and twenty-sixth parallels of latitude. Jade is also found at Mawhun in the Myadaung district, and the most celebrated of all jade deposits is reported to be a large cliff overhanging the Chindwin, or a branch of that river, and distant eight or nine days' journey from the confluence of the Uru and Chindwin. Of this cliff, called by the Chinese traders Nantelung,[8] nothing is really known, as no traders have gone there for at least twenty years. Within the jade tract described above, however, small quantities have been found at many places, and abandoned quarries are numerous. The last old quarry is Sanka, situated seventy miles northwest of Mogaung. The largest quarries now being worked are Tomo, Pangmo, Iku, Maikenmo, and Mienmo; they are distant about eight miles from Sanka. These mines are situated in the country of the Merip Kachins. The largest mine is about fifty yards long, forty broad, and twenty feet deep. The season for jade operations begins in November and lasts until May. The most productive quarries are generally flooded, and the labor of quarrying is much increased thereby. In February and March, when the floor of the pit can be kept dry for a few hours by bailing, immense fires are lighted at the base of the stone. A careful watch is then kept in a tremendous heat to detect the first signs of splitting. When these occur the Kachins attack the stone with pickaxes and hammers, or detach portions by hauling or by levers inserted in the cracks. The heat is almost insupportable, the labor severe, and the mortality among the workers is high."

[1] Cf. Noetling, op. cit. infra, p. 3.

[2] Hannay, Journal Asiatic Soc. (Bengal, 1837), VI, 265 ff.

[3] This is no doubt a transcriber's error for Chinese *yü-shê*, or *yü-shih*, "jade stone." The Burmese name for the mineral is *kyouk-sein*.—NOTE BY THE EDITOR.

[4] Griffith, Journal of Travels in Assam, Burma, Butan, etc. (Calcutta, 1847), p. 132.

[5] Yule, Narrative of the Mission to the Court of Ava (London, 1858), p. 146.

[6] Report on the Expedition to Western Yunnan viâ Bhamo (Calcutta, 1871), p. 66.

[7] Report on the Administration of Burma for 1887–88 (Rangoon, 1888), p. 59. Abstract in Watt, Dict. of the Econ. Prod. of India, 1890, IV, 536 ff.

[8] Properly *Nan-tê-ling*, meaning "mountain-ridge difficult of access."—NOTE BY THE EDITOR.

The last and by far the best work which has been done on the locality is that by Dr. Fritz Noetling[1] and Dr. Max Bauer.[2] The former visited the locality and describes it geologically. The latter examined petrographically the material brought back by Noetling.

From Noetling's description the following is quoted: "As far as our present knowledge goes, the occurrence of jadeite in Upper Burma is confined to a small spot on the upper course of the Uru River. It cannot be told at present whether it occurs elsewhere, though in my opinion this is not improbable. Jadeite pebbles are said to have been found in the alluvium of the Irawadi above Myitkyina. . . . The following remarks therefore are confined to the occurrence on the Uru. As the centre of the jade-producing district one can take the village of Tammaw, which lies in about 25° 44′ N. Lat. and 96° 14′ E. Long. It must be remarked that Tammaw is not a permanent settlement, but is abandoned by the workmen during the rainy season. A permanent place of residence is the Kachin village of Sanka, which lies about six miles to the east. Inside this district the jadeite is obtained in two ways, from the alluvium of the Uru River and from quarries near Tammaw."

The author then describes the general geology of the country, and shows that crystalline schists, limestones of probably Carboniferous age, Miocene sedimentaries, alluvium, and eruptive rocks occur. Basalts occur along the Irrawaddy to the east and also near Sanka. Serpentine occurs at two places, at one of which—Tammaw—in connection with jadeite. This is described as follows:

"The second serpentine occurrence, which is the one which interests us most here, is situated west of the village of Sanka, on the top of a plateau, which, as far as known, consists entirely of Tertiary sandstones. The serpentine occurs here in the form of a low knoll, which is, however, visible at present only at the east side of the quarry, and which apparently passes under the Tertiary strata toward the east side.

"Below the serpentine, but separated from it by a crack which is about half a metre wide and which is filled with soft, friable rock, the jadeite occurs, which offers a sharp contrast to the dark serpentine by its dazzling white color.

"The quarry operations have opened a pit about one hundred metres long and extending from east to west, but the walls of this have unfortunately fallen down except at the west side. I could not therefore determine exactly what rock was in place on the other sides, since outside the excavations an impenetrable thicket made all investigation impossible. But according to the inquiries which I made, the workmen came again upon the dark rock after penetrating the jadeite, especially on the west side. One thing was very plainly evident: the quarrying moved generally towards the east, while the floor of the quarry sank gradually in the same direction. I consider that this goes to show that the jadeite passes under the serpentine, at least in this direction. The distinct crevice which, also with an eastward dip, separates the serpentine and jadeite, and by which much water reaches the surface, appears to point to a tectonic disturbance, which implies that the relation between the serpentine and the jadeite is not as intimate as it appears to be at first sight.

"From these observations the following definite conclusions may be drawn:

"1. The jadeite crops out below the serpentine, but at least at one place is separated from it by a crevice.

"2. The serpentine and the accompanying jadeite are surrounded on all sides by Tertiary sandstone, although no contacts between the two could be observed.

"This occurrence admits of two explanations. The jadeite and serpentine may have formed, at the time of the deposition of the Tertiary strata, a knoll about which the Miocene sandstone was deposited. . . . Or the serpentine may be of eruptive origin, in which case it would be of post-Tertiary date. In this case the jadeite may be either a mass brought up from below by the serpentine, or it may be due to a later eruption of jadeite."

Between these alternatives Noetling is unable to decide, but he is inclined to regard the serpentine at any rate as eruptive, on the ground of other occurrences in Burma.

Bauer's examination, together with the chemical analyses of Busz, establishes the fact that the jade is a

[1] Noetling, Rec. Geol. Surv. India, 1893, XXVI; also Neu. Jahrb. Min., 1896, I, 1–17. Map on Taf. I.
[2] Bauer, Rec. Geol. Surv. India, 1895, XXVIII, 91; Neu. Jahrb., 1896, I, 18–51.

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No. 439

BEAKER-SHAPED VASE

(*Hua Ku*)

K'ang-hsi (1662–1722)

Nephrite

true jadeite. Bauer also describes the serpentine from this locality, which shows a somewhat cataclastic structure, and contains considerable (forty-three per centum) unaltered olivine. An albite-hornblende rock and a glaucophane-schist, both from boulders at the locality, are also described. His conclusions on the geological age and mode of occurrence of the jadeite and serpentine are of great interest, and are quoted here in full.

"From the above description of the rocks occurring in the jadeite mines at Tammaw, viz., the jadeite, the olivine-serpentine, the albite-hornblende rock, and the amphibole-glaucophane-schist, we are enabled to form a clear conception of their nature. Noetling believes that the jadeite and the serpentine penetrate the surrounding Tertiary sandstone, while with regard to the relations between the occurrence of the two other rocks and the jadeite nothing is known. Noetling's view necessitates the assumption of an eruption of jadeite and another of olivine rock, following one another; but the petrological composition of these rocks is not favorable to such a view, which would include them among the Tertiary eruptive rocks. Judging by the petrological characters, we must consider them as representing a system of crystalline schists.

"Now there is no doubt that in former geological times olivine rocks were produced by volcanic eruption. Nowhere, however, have rocks of this nature been found in beds of such modern date, being, according to Noetling, not older than of Miocene age. Wherever Tertiary masses of olivine are known to occur, as for example the enclosures in basalt, they are perfectly fresh, and show no signs of serpentinization. I wish particularly to emphasize this fact, since the basalt, which I shall presently describe, and which occurs in close proximity to the jadeite mines, has no geological connection with the jadeite, but is unquestionably an eruptive rock passing through Tertiary strata. In this basalt the serpentinization of the olivine has just begun, but has not progressed beyond the first stages, while such a complete alteration as that exhibited in the above specimens is characteristic of all ancient olivine rocks—such as palæopikrite—and, as I have already observed, of the crystalline schists.

"To consider the jadeite as an eruptive rock would be entirely unjustifiable; for neither in the older, nor yet in the more recent, eruptive rocks has any rock of the nature of jadeite been found. In Turkistan, however, it has been proved to be embedded with nephrite in the crystalline schists (gneiss and mica-schist), and belongs to that series.

"The other two rocks also offer material proof in favor of this view, for it is highly probable that the glaucophane-schist is one of the crystalline schists. Hitherto, glaucophane has been found only in gneissic rocks and mica-schists, no instance having been recorded of its occurrence in eruptive rocks, much less of its entirely composing such rocks. The same holds good for the albite of the albite-hornblende rock. This mineral frequently occurs as a component part of the crystalline schists, but hardly of eruptive rocks. The peculiar aggregation of the albite grains is in perfect harmony with this view, for such a structure would be by no means remarkable in a crystalline schist. I am therefore of opinion that the jadeite and the other rocks must be looked upon as part of the series of crystalline schists, overlaid by Tertiary beds and probably denuded by erosion. It is most probable that they were raised to their present level together with the surrounding Tertiary rocks, when these latter were subjected to folding. I have repeatedly laid stress on the fact that these rocks must have been subjected to great pressure, which can only be accounted for by folding. I do not assert for a moment that the above arguments are absolutely convincing, but they certainly support the view which best accords with the petrological evidence, while the stratigraphical conditions observed by Noetling in the mines at Tammaw fully bear out this view. Further observations, however, with regard to the geological conditions of that country, will certainly decide the question. On the geological map of Burma, west of the Irrawadi, even west of Mogaung, towards Tammaw, submetamorphic rocks are indicated; while crystalline limestones, probably of Silurian age, extend to within about two miles of the eastern side of the jadeite mines."

It will be seen from the above that, while Noetling is unable to decide from field evidence the question of the origin of the jadeite, Bauer is decidedly of the opinion "that the jadeite and the other rocks must be looked upon as part of the series of crystalline schists." This account of Bauer has already been referred to by Pirsson, who, to a great extent, bases upon these observations his conclusions as to the origin of jadeite, as set forth in an earlier section of this work.

India

Although Fischer[1] is rather sceptical about the occurrence of jade in India, yet certain observations of the Geological Survey of India leave little doubt that it does occur in several places in Central India, though apparently only to a small extent. It is not stated whether any mining is done at these localities or not.

The best-described occurrence is in the small state of Rewa, where it is associated with corundum.[2] A section from south to north across a small hill between Pipra and Kadopani is as follows:

(*a*) White quartz-schist.
(*b*) Hornblende-rock passing into jade, a few yards thick.
(*c*) White tremolitic quartz-schist.
(*d*) White and green jade, including some purple corundum and containing euphyllite and schorl.
(*e*) Bed of corundum, several yards thick.
(*f*) Porphyritic gneiss with hornblende-rock.

It is also stated elsewhere[3] that in south Mirzapur (which is east of Rewa) "the hornblende-rock west of Dumrahur and Urijhut passes into a finely granular to nearly compact tremolite forming coarse jade, and that this last is also found between Kotomowa and Bhamni and at the top of Kurea Ghât. An olive-green jade also occurs northwest of Kisari."

It is uncertain, in the absence of mineralogical and chemical details, whether the material spoken of as jade is really so or not, and, if so, whether it is jadeite or nephrite. Since the geologists of the Indian Survey were undoubtedly well acquainted with jade, it can scarcely be doubted that what they called jade was really that material. Whether it was jadeite or nephrite is another matter, but the transition from a hornblende-rock to the jade points with some probability to the latter, at least in some cases. It is to be noted that the section at Pipra points unmistakably to a metamorphic complex, and that all the localities mentioned lie in the area of the Bengal gneiss.

An examination of the specimens from India in the Collection is of great interest in this connection. These—or at least the greater part of them—are easily distinguished by the trained eye (some even by the casual observer) from the jades of Burma, the K'un Lun, and other localities, by their peculiar texture and color. The marked character and general constancy of this individuality, taken together with the fact that the microscopical, chemical, and specific gravity examinations show that these Indian jades are all nephrite,[4] would indicate that a large part of the material comes from one locality, and that it is native—*i. e.*, of Indian origin. It is difficult, and has been so far impossible, to ascertain the exact location, or even the existence, of such quarries or other sources, but from the occurrences just mentioned it is to be presumed that they exist in Central India. It will be recalled that the indications here were that the jade was nephrite.

Turkistan

The localities of jade in this region are among the most important in the world, and apparently the longest known, to Europeans at least. They were first noticed by Marco Polo (1271–1313), and afterward by a number of other writers. They are also fairly well known geologically, having been investigated by several modern travellers. The localities are all in the K'un Lun Mountains south of Khotan, in southeastern Turkistan. The jades of this region are true nephrites, both white and green, and jadeite does not seem to occur abundantly.[5]

The first reliable investigation was that of the brothers Schlagintweit in 1856 and 1857. H. von Schlagintweit[6] describes the localities as follows, his remarks, on account of their importance, being transcribed verbatim (with some small omissions).

[1] H. Fischer, Jadeit und Nephrit, 1880, p. 323.

[2] Cf. Manual of the Geology of India. Economic Geology. Part I, Corundum, 1898, p. 50.

[3] Dictionary of the Economic Products of India, 1890, IV, 385.

[4] In the Collection there is but one exception to this general statement, No. 781, a beautifully jewelled butterfly with wings of brilliant emerald-green jadeite. The workmanship is decidedly Indian in style. No microscopical or chemical examination of it has been made.

[5] Schoetensack (Inaug. Diss. Univ. Freiburg. Berlin, 1885) describes some specimens brought by Von Schlagintweit which are partly of nephrite and partly of jadeite.

[6] Von Schlagintweit, Sitz. ber. d. Math. phys. Classe. Akad. Wiss. (München, 1873), III, 236–242.

"We found nephrite *in situ* in Khotan on both slopes of the K'un Lun Range. In 1856 and 1857 we found at the northern boundary of the nephrite area large groups of quarries near Gulbashen, a station on the right bank of the Karakash River, in longitude 78° 15′ east of Greenwich and latitude 36° 13′ north, at an elevation of 12,252 feet. These quarries appear to be abandoned: they were deserted in both years.

"One group of quarries, which we were informed was called Konakan, is close to Gulbashen; the other, called Karala, about six and a half miles down the valley. In both, the outcrop of nephrite is only a little higher than the floor of the valley, which here separates the northern slope of the Karakorum chain from the southern slope of the K'un Lun chain.

"The road from the river to the Konakan quarries leads along a talus slope, which contains many pieces of nephrite, derived partly from weathering and partly from blocks fallen from the workings. The masses of nephrite in the large quarries are evidently *in situ*, and indeed a metamorphic phase[1] of the crystalline rocks generally parallel in dip and strike with the foliation (*? Zerkluftung*) of the rocks which bound it; though in the nephrite mass itself no such foliation (?) is found. The direction of strike of the foliation (?) planes is about the same as that of the slope of the mountain down toward the river, but their dip is steeper than that of the mountain slope, so that the whole succession and mutual relations of the rocks are visible.

"The prevailing rock in the Konakan quarries is gneiss, granite also occurring, but in smaller amount. It occurs both above and below the nephrite, but near the nephrite itself greenstone (or 'diorite') occurs on both sides, which penetrates the gneiss for short distances.

"The diorite is a mixture of hornblende and feldspar, in which orthoclase occurs sporadically, while albite is predominant. The rock is very compact. The diorite does not penetrate the nephrite as it does the gneiss, but is on the contrary separated from it by a layer of altered substance of varying thickness.

"The Karala quarries proved to be very similar to the above in their rock structure, though the nephrite occurs in even greater quantities. At Karala the rocks of the mountain slope are micaceous and dioritic. They are not as pure as the gneiss and diorite of Konakan, but are likewise very compact. The layers of soft, friable substance in connection with the nephrite are thicker. This is partly yellow and partly red, and is evidently a product of decomposition by percolating water, mixed with talc. It is certainly not a tectonic fissure. The strata of nephrite are also here much greater, from twenty to forty feet thick. The thickness could be measured directly in places which had been quarried and which showed the rock in profile. It is possible that this thickness of pure nephrite is continued still deeper in the mountain, yet the mass of nephrite seems in general to be underlain at some depth by the very variable crystalline rocks. It does not form a dike or stock, but is clearly interstratified, the stratum running along the slope, with the strike parallel to that of the foliation. In the nephrite masses only joint planes occur which differ in origin and position from the fissures of the surrounding rocks.

"At a greater altitude, nearer the crest of the K'un Lun, along the south slope, no additional nephrite was met with, either along our line of march over the Elchi Pass, or over the Kilian Pass west of this. Along the latter diorite is the prevailing rock as far as the pass. Granular varieties of gneiss frequently occur, as well as gray schists in thin strips. Foliation is always evident. Our route over the Elchi Pass showed that this was quite analogous to the Kilian Pass, geologically. On the north slope of the K'un Lun, as far as the border of the plains of Turkistan, no more nephrite was seen along the route. This does not occur at all west of the province of Khotan.

"On the road from Elchi Pass to Elchi, the chief city of Khotan, however, there are two nephrite quarries. We ourselves could not visit these quarries on account of political difficulties, but Mohammad Amin knew of them and had told of them in an official report which he made in 1862 at Lahore. The upper of the quarries is at Amsha, a small village about twenty-five English miles from Elchi. This quarry does not appear to be any longer in use. Those layers at least which are exposed in the present condition of the quarry show relatively little pure nephrite. The quarries near the village of Kamat are far more promising. The quality of the nephrite found there *in situ* is so excellent that it finds a ready sale. The situation near the edge of the mountain, and its distance of only fifteen miles from Elchi, at a height greater by fifteen hundred feet, favor the distribution of the quarried material.

[1] The meaning here is not quite clear, but the metamorphic character of the occurrence is evident.—H. S. W.

"Nephrite is found as river-boulders as far as the plains of eastern Turkistan. The rivers in which such boulders are found are: the Karakash, the Khotan, the Yurungkash, and the Keria.[1] I know nothing of the occurrence of nephrite pebbles in the Yarkand River, which is west of the Karakash. This seems to confirm the absence of nephrite in the province of Yarkand."

Von Schlagintweit also refers briefly to short accounts by a few travellers who have visited the localities, but which add little of value here. Dr. H. Cayley, who travelled through the country in 1868, and who is mentioned by Von Schlagintweit, published later an account of the jade-mines which closely corresponds to that of Von Schlagintweit, and need not be quoted here.[2]

Somewhat later the occurrence of jade at these localities was described by Dr. F. Stoliczka, geologist of the Indian Geological Survey.[3] An abstract has been given (pages 27, 28) in Dr. Bushell's account of Chinese Turkistan.

A locality of jade boulders near Ilchi (the chief town of Khotan) has been visited recently by Svèn Hedin, who speaks of it thus:[4] "I made an excursion to the village of Kaltakumat (Short Sand), situated two and a half *potais* (six and one quarter miles) northeast of Ilchi. To reach it I had to ford the river Yurungkash. On the other side of Tamaghil (the Stone Village) the desert began, with occasional sand-dunes and ravines left behind by the stream. After that the ground became excessively stony, and I soon perceived that we were riding along an old river-bed.

"This disused river-bed is one of the places that yield the largest supplies of jade. Everywhere the ground was cut by trenches six or seven feet deep, a few feet wide and at most thirty feet long, although varying somewhat as regards size according to the amount of work done in them. The material which is thrown up out of the trenches consists of round, polished stones, sand, and clay. It is among these stones that the jade is found."

Some of these pebbles obtained by Svèn Hedin are at present in the Collection (Nos. 61, 62, and 63), as well as several hundred from the Yurangkásh and Karakásh rivers in Khotan, obtained from Peking (Nos. 60, 65, and 66).

It must be added that Professor Hintze[5] says that nephrite occurs *in situ* on the Raskam Daria, a tributary of the Yárkand Daria (three or four degrees west of the city of Khotan), and that the Yárkand also contains boulders of nephrite which resemble the material of the great monolith on the tomb of Timur at Samarkand. (Since this was written the Collection has been enriched by receiving from Professor Muschketow, the finder, two fine specimens from this locality, Nos. 70 and 75.)

Siberia

The fact that jade occurs in Siberia has long been known, though some of that brought from Kolywan, the earliest-mentioned locality, has been shown to be really prehnite. A number of writers[6] have described nephrites from the province of Irkutsk near Lake Baikal, in eastern Siberia, and from rivers flowing north from the Sayan Mountains, in south-central Siberia. All these refer, however, to jade occurring as boulders or transported blocks. It is only within the last few years that jade (nephrite) has been found in Siberia undeniably *in situ*. This has been done by Professor L. von Jaczewski, whose account (slightly abridged), written specially for this work, is here given:

JACZEWSKI'S EXPLORATIONS

Renovanz (1744–98) reported the occurrence of nephrite in the Altai, but later investigations have not confirmed his statements.

The first reports about nephrite in the Belaja river system date from the beginning of the nineteenth

[1] The author shows that all these drain from the K'un Lun Mountains.
[2] Cayley, Macmillan's Magazine, 1871, XXIV, 472.
[3] Stoliczka, Quart. Jour. Geol. Soc., 1874, XXX, 568–570.
[4] Hedin, Through Asia (New York, 1899), II, 738.
[5] Schlesische Zeitung, Breslau, June 21, 1899.
[6] Von Fellenberg, Neues Jahrb., 1871, p. 173; Geinitz, Neues Jahrb., 1873, p. 916; Jannetaz and Michel, Bull. Soc. Min. de France, 1881, IV, 178; Beck and Muschketow, Verh. Russ. Min. Ges. (2), XVIII, 9–33, 188; Arzruni, Zeit. für Kryst., 1885, p. 510.

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No. 384

RECTANGULAR VASE

(*Fang Chüeh*)

Ming Dynasty (1368–1644)

Nephrite

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century, but systematic investigations were not made until 1850, when Permikin was sent out by the imperial court ministry to find nephrite for the stone-cutting establishment at Peterhof.

Permikin found a great number of nephrite blocks on the lower part of the Onot River and along the borders of the Dajalock. Among the papers and maps left by him were found notes regarding an occurrence *in situ* of the mineral on the brook Zagan-Chori.

Tschersky, the well-known Siberian explorer, made an unsuccessful search, under very unfavorable circumstances, along the Zagan-Chori brook and in the upper course of the Onot; and Bogdanowitsch, in 1894, was prevented by heavy rains from reaching the Dajalock River, where he had hoped to find nephrite *in situ*.

In 1895 I made a short trip to the river Onot, penetrated to the mouth of the Usin, and reached above the latter a narrow pass—a real cañon—which I could not enter. I then turned back. The result of this expedition revealed the important fact that nephrite *in situ* must be sought for at points much further up the river than those at which Permikin found his blocks.

In 1896 his Majesty's cabinet invited me to search for nephrite *in situ* for the purpose of procuring a monolith for a sarcophagus to be placed on the grave of the emperor Alexander III. My work lasted two years, 1896 and 1897. Incessant rains rendered the first year almost barren of results.

The region explored forms a part of the Sajan mountain system. This part lies between the upper course of the Kitoi on the south, the Urick River on the west, the lower course of the Belaja River on the north, and the Onot River on the east.

To reach this region the traveller uses the great Siberian railroad to the Tscheremshowo station, whence a Siberian tarantass takes him southward for a distance of fifty versts to a village called Golumeteiskoje, where he must organize a mounted caravan to penetrate the uninhabited, utterly wild, and mountainous Taiga. The caravan must needs be large, as a month is required to visit all the nephrite finding-places, and provisions have to be taken along for all that period. So far as the mounts are concerned, the Russian and Burjat horses can be used only for the trip along the lower course of the Onot and Urick. Along the upper courses, where serious obstacles are to be overcome, they must be exchanged for Sojot horses, which are used to travelling on uncommonly steep mountains and ledges, while able to live on the scantiest grass diet.

A very good road leads from the village of Golumetei to the last Russian blockhouse on the Onot, a distance of about forty versts, according to general calculations. At this point begin the Taiga and the mountain region, with their scenic beauties and obstacles.

For a further distance of about fifty versts—*i. e.*, to the mouth of the Ugungol—there is a narrow footpath occasionally used by hunters, but from that point onward the traveller must make his own road. The river runs in cascades and waterfalls, and rocks reaching up to one hundred metres in height block the advance on either way. Consequently it is necessary to wade from one bank to the other. These crossings are often very difficult, and fords are few; therefore one must either build a raft or, as I did after my experience in 1896, use canvas boats. These serve to ferry the travellers and their packs across; the horses must swim.

In a few cases the members of the expedition were exposed to serious danger in these boats, while some of the horses were carried away and drowned. Three or four crossings had to be made in the course of a day's journey, with the result that the distance covered sometimes amounted to only two to five kilometres, and never to more than twenty-five.

Where the Onot passes through the cañon, it was necessary to carry the packs up high mountains, and to pull the horses up with ropes. It should be added that the Burjats and Sojots, like the Russians, understand how to overcome seemingly insuperable difficulties. The Sojots will climb up an almost perpendicular mountain like chamois.

With few exceptions, the whole journey had to be made through territory of this character.

The following marches were made in search of nephrite deposits:

The Onot and Urick rivers and Dajalock and Zagan-Chori rivers were followed from beginning to end, while, in addition, excursions were made to right and left into the country lying between them.

Orographic Characteristics

I apply the name "Sajan mountain region" to the tableland which begins on the right bank of the Yenissei, embraces the whole southern part of Siberia, and ends in the east with the meridian of Selengo. Toward the south this tableland merges into Mongolia. At the north it ends abruptly with a considerable scarp, running from southeast to northwest, and just south of the great Siberian railway. This immense tableland owes its present aspect to tectonic and erosive processes. The former have brought about the general outline; the latter have chiselled the details of the design. In Siberia the highest points of this tableland are grouped along the mountainous chain on its border, some of them reaching an altitude of three thousand metres. Toward the north, the elevations diminish gradually.

The deeply cut river valleys have divided the Sajan tableland into a few rather well-defined mountain ranges, the Tankins and Kitoi Alps, and a whole chain of mountains which follow more or less a north-and-south direction.

To give the reader some idea of the elevation of this region, I add here the following figures:

On the northern border of the scarp, the foot of the terrace is situated at an altitude of about 650 metres; the terrace itself reaches at its crest a height of 800 metres.

In the Kitoi Alps the separating ridge from the sources of the Onot (Osspa) to the Zagan-Chori is situated at an altitude of 2608 metres; the neighboring basalt peaks overtop the ridge by at least 3000 metres. The Chalbin mountain ridge rises to an altitude of 2315 metres.

One can form some idea of the nature of the Onot and Urick rivers from the figures of their fall. Thus, the Urick has a fall of more than 400 metres in a distance of 100 kilometres along its lower course, between the Gadshirskoje blockhouse and the mouth of the Chonschon.

Geological Characteristics

The Sajan tableland is bordered on its northern side along the scarp-line by old palæozoic deposits, which are generally classed with the Cambrian. These deposits are occasionally covered by overthrust older crystalline schists.

Below the surface, the tableland consists of metamorphic schists and different varieties of gneiss and granite. These are cut by thick dikes of diabase and gabbro, which furnished the material for the serpentine now so generally present.

The basalts reach a high degree of development. They cover the greater part of the region with a sheet reaching a thickness of three hundred metres in some spots. They have flowed into the valleys, which have a general direction from north to south. These basalts have determined the table form of many of the peaks, particularly in the northern part of the Kitoi valley.

So far as the nephrite deposits are concerned, the chief interest centres in a group of metamorphic schists which, petrographically considered, show considerable diversity. Here we have argillaceous schists (?Tonschiefer) changing into phyllitic schists, talc, chlorite, mica, and actinolite schists. A whole series of schists here are a product of mechanical change from diabases. The strata of all these schists are much disturbed, and many are much folded. It is not only the schists, however, that bear strong traces of mechanical deformation, but also all the other rock varieties, the basalts forming the only exception.

The Nephrite Deposits

The primary deposit of nephrite was found at an altitude of about two thousand metres on the Chara-Shelga, a tributary on the right bank of the upper course of the Urick (or Chorock). This brook, which is but fifteen kilometres long, flows from south-southwest to north-northeast, almost at right angles to the direction of the strike of the strongly crushed and much folded schists. In its lower course argillaceous

schists are in immediate contact with limestone, through which the Chorock forces its way in a gorge several hundred metres deep, and so narrow that the *kabargi* (chamois) can jump it with ease.

Farther up the course of the Chara-Shelga only dike-like, actinolitic schists occur, which have to a great extent been changed into serpentine, and contain large aggregations of nephrite. Still farther up, these are supplanted by granite, which, in turn, is succeeded by argillaceous and actinolitic schists. The latter of these have been changed into nephrite. The remaining products of the hydrodynamic change are serpentine and magnetite schists, which remind one of listwanite. The depth of these nephrite deposits can be estimated at the places where the mineral crops out. It reaches here a depth of six metres and more. The nephrite has a beautiful color, almost emerald-green. A characteristic admixture is graphite.

A primary deposit of nephrite is found on the Onot, near the mouth of a brook called Tehe-Cher. I did not search here for the primary deposits, as the Cabinet considered this unnecessary. The many sharp-edged nephrite blocks found here, which reached a diameter of six metres, demonstrate that the discovery of the vein itself would offer no difficulties.

In the same way, only superficial search was made on the Zagan-Chori; but here, too, nephrite blocks were found. Following the information vouchsafed by the Sojots, I found the spot, near a larch tree, where, fifty years before, Permikin had made a mark. Nephrite did not break through at this spot, however; but on this stream, too, the search for the deposits would offer no difficulties.

As for the Dajalock, no nephrite was found in the valley through which it runs. This should not be taken, however, as evidence that the mineral does not occur there. When I visited the Dajalock, my researches were seriously hampered by torrents of rain, so that my failure should not be regarded as final.

The question of the occurrence of primary deposits of nephrite in Central Siberia may thus be considered as settled. The results obtained are more than sufficient for the purpose for which the investigations were made.

The mineral, which fully deserves the name of "rock," occurs in such vast quantities and masses that not only sarcophagi, large vases, and similar objects can be cut from it, but also whole columns and monuments.

It is evident from this description of Jaczewski's that the Siberian nephrite, as observed *in situ*, occurs in connection with a metamorphic complex, analogously to its occurrence elsewhere (as, *e. g.*, in the K'un Lun), being found in close association with gneisses and schists of various kinds.[1]

Although the work of Beck and Muschketow is confined entirely to the examination of pieces not *in situ*, yet, for the sake of completeness, it will be well to give a list of the localities mentioned by them.[2] These are: Belaja River in Transbaikal, Kitoi River in the Nertchinsk mining district, Bustraja River in Irkutsk Province, and several other localities, the so-called jades of which turned out to be serpentine, garnet, or other material.

China

The great fondness of the Chinese for jade, and the very large number of beautifully decorated pieces which come from China, lead many to suppose that jade occurs there. In point of fact, however, not a single locality where either jadeite or nephrite is certainly known to be mined can be mentioned. Pumpelly[3] mentions several localities: six in Shensi, four in Yunnan, and one in Kweichow; but he himself never visited these provinces; and he tells us in a private communication that he relied on the statements of Chinese books. The term *yü* found in these works, usually translated "jade" by foreigners, really includes several other minerals besides jade,—*e. g.*, steatite, serpentine, and generally all the beautiful stones and minerals prized by the Chinese,—so that when *yü* is stated to occur in any locality, the mineral is not necessarily jade. Undoubtedly the great majority of the beautiful jade objects found in that country, and so well exemplified in the Collection, were made of nephrite from Chinese Turkistan or of jadeite from Burma. Possibly the Siberian nephrite has been used; but if so, only to a small extent, and the same is true of the New Zealand

[1] Saytzeff (Ref. in Neu. Jahrb., 1897, I, 286) describes petrographically some of the rocks of the Sayansk Mountains, among which are mentioned syenites, gabbros, and gneisses.

[2] Beck and Muschketow, Verh. K. Min. Ges. (St. Petersburg, 1882), XVIII, 1–76.

[3] Smithsonian Contributions, 1866, No. 202, p. 117.

nephrite. But though we have no certain knowledge of the occurrence of true jade *in situ*, the possibility of jade being yet found in China proper is evidenced by the four pebbles (Nos. 85–88) in the Collection stated to have come from the Liu Yang River, which rises in the western part of Kiangsi and flows westward to the Siang River at Chang-Sha Fu in Central China. There seems to be no reason to doubt the correctness of the provenance of these specimens, which are therefore of importance as establishing the possibility of the occurrence of jade in China.

EUROPE

Jordansmühl

ALTHOUGH boulders and worked objects in jade had been known in Europe for many years, it was not till 1884 that jade (nephrite) was discovered *in situ* in this quarter of the globe. The very great importance of this discovery, as bearing on many archæological problems, is evident, and is dealt with in another part of this work.[1]

The discovery was made near Jordansmühl, southwest of Breslau, in Silesia, by H. Traube, who announced it in a short note.[2] In a later paper[3] he describes the occurrence at some length, from which we abstract the following:

"The nephrite occurs in connection with granulite or serpentine, which, together with 'gabbro,' forms a low range of hills stretching in a northwesterly direction from Jordansmühl to Naselwitz, the so-called Steinberge (Stone Mountains). The gabbro[4] occurs only in the northwestern spurs. Near Jordansmühl itself the serpentine is exposed to a considerable depth in a large quarry, which has been worked for a long time, and in which also granulite crops out. In this locality the latter penetrates the serpentine as a wedge-shaped ridge, which increases in size towards the bottom, so that the serpentine overlies it, as it does elsewhere in the Zobten region, as, *e. g.*, at Mlietsch.

"The nephrite occurs at the contact of the granulite and serpentine, and accompanies both of them for long distances, in layers which are often over a foot in thickness. The nephrite also occurs in the serpentine itself as small inclusions and knobs, which, however, are always near the granulite contact. It is to be remarked that the nephrite enclosed in the serpentine is always light, while the others show darker colors.

"As the nephrite is approached, the granulite, which is composed essentially of quartz, orthoclase, and plagioclase, and a little mica, changes in composition in a remarkable way. The feldspar is altered almost completely to compact epidote and zoisite, the quartz and mica disappear, and a green, finely fibrous hornblende appears as a new component. Under the microscope the last appears perfectly colorless, much frayed, and shows between crossed nicols a structure analogous to that of nephrite. . . . As the junction is approached the hornblende predominates more and more, until the last zone of the rock is such an intimate mixture of hornblende and epidote that the two cannot be distinguished by the naked eye. The microscope shows that pyroxene also enters as a new component.

"Both hornblende and pyroxene in this rock are still very fresh with spindle-shaped outlines, but can be discriminated with difficulty, since cleavage is seldom to be seen. A transition of the pyroxene to nephrite through the setting up of a fibrous structure (uralitization) is unmistakable in many places.

"The more the zoisite disappears the finer-grained becomes the rock, until finally it is seen to be composed of small, flattened, nearly round grains, which do not admit of sure determination as either amphibole or pyroxene. In general, however, they would seem to be the latter, at least judging from the change into nephrite, which is constantly observed, and which can only take place with pyroxene. This nephrite is composed of short, thick, interwoven bundles of fibres." An analysis gave:

Silica, SiO_2	57.26
Magnesia, MgO . .	19.96
Lime, CaO	13.19
Ferric oxide, Fe_2O_3 .	4.22
Manganous oxide, MnO	.74
Alumina, Al_2O_3 . .	1.40
Water, H_2O . . .	2.53
	99.30

It will be seen from this that this pyroxene-amphibole rock does not differ materially from nephrite in chemical composition.

[1] Cf., on this point, Hintze, Schlesische Zeitung, Breslau, June 21, 1899.

[2] Traube, Leopoldina, 1884, XX, Nos. 7, 8.

[3] Traube, Neu. Jahrb., Beil. Band., 1885, III, 412–427.

[4] These gabbros of Traube are the zobtenites of J. Roth — *i. e.*, rocks with the mineralogical and chemical characters of true eruptive gabbros, but metamorphic in origin. They are probably metamorphosed eruptive gabbros.

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No. 704

BEAKER-SHAPED VASE

(*Ku T'ung Hua Ku*)

Chia-ch'ing (1796–1820)

Nephrite

"Green nephrite proper usually comes next to the above-described rock. Sometimes the pyroxene-amphibole rock alternates with layers of compact zoisite, but again this appears to be lacking entirely, especially when the nephrite (which borders the granulite) is coarse-fibred."

The microscopic characters of thin sections of the nephrite are given by the author in great detail, many of them being shown to resemble the nephrites of New Caledonia, though there is considerable variety.

"Arzruni[1] has reached the conclusion, based on the results of his examination of nearly all the different nephrites known thus far, that the nephrites are partly of primary origin and partly due to the uralitization of pyroxene. The former are called primary nephrites, the latter pyroxene-nephrites. The dark-green nephrite of Jordansmühl described above appears to be derived from pyroxene. A secondary origin would consequently have to be ascribed to the greater part of the hornblende.

"The far rarer light-colored nephrites occurring in serpentine differ in many respects from those just described. The Jordansmühl serpentine is derived exclusively from diallage. No traces of original olivine, which can be seen in other localities of the Zobten district, could be found here. The alteration of the diallage is generally far advanced, but remains of microscopic bastites are frequently to be observed. The rock which surrounds the nephrite appears to be much fresher."

The characters of these nephrites are described in detail and the conclusion reached that "The nephrites which occur in serpentine differ from those which occur in connection with granulite not only in their structure, which is usually perfectly schistose, but also in their composition, since here primary amphibole plays a prominent rôle. Consequently this nephrite may be considered on the whole as primary nephrite proper, even though pyroxene may have contributed in part to its formation."

The author goes on to remark that the Jordansmühl nephrites show peculiarities of structure and appearance which differentiate them from all other known nephrites, though on a former page he had noted their general similarity to those of New Caledonia.

"The original relations of the nephrite of Jordansmühl to the diallage rock, the mother rock of the serpentine, and the granulite, may perhaps be represented by the assumption of the former existence of a zone of pyroxene rock rich in finely fibrous amphibole between the diallage rock and the granulite, both of which at this point contained finely fibrous hornblendes. Furthermore, an analogous rock would have formed the inclusions and bands in the diallage rock, though here finely fibrous, nephritic amphibole surpassed the pyroxene in quantity."

In his final paragraph the author points out the great similarity obtaining in the conditions and character of the occurrences both at Jordansmühl and at the K'un Lun quarries.

In April, 1899, Mr. George F. Kunz visited this jade locality accompanied by Lieutenant Oscar von Kriegsheim, on whose estate it is, and secured many good-sized specimens of nephrite, including one large block weighing 2140 kilogrammes, now in the Collection and numbered 134.

He describes the finding-place as "a quarry forming a gap 400 feet long and 200 feet deep in what was originally a low hill probably 600 feet in length and 300 in width, with a central height of 70 to 80 feet above the floor of the quarry, which at its entrance is on a level with the surrounding plain. At the left on entering stood large columnar masses of a white and flesh-colored quartzite, rising to a height of twenty-five feet from the floor of the quarry, and varying from three to twenty feet in width, with a slight dip to the north. They had been left by the quarrymen when they removed the softer surrounding serpentine. About fifty feet to the southwest of these quartzite masses the floor of the quarry seemed to be some eight to ten feet higher than elsewhere. A blow of the hammer showed that this was a bed of nephrite that had been passed over by the workmen owing to the difficulty of quarrying it. Near the central point of the quarry a mass of serpentine and talcose schists and apparently altered nephrite was found in a vein of serpentine which had a dip of 55° to the north, the vein rounding at the edges and presenting a bow-like appearance.

"The serpentine is overlain by a deposit of loess varying in depth from one foot to six feet, and in this was found a large piece of rich red syenite." Mr. Kunz further adds that "it is interesting to note that the nephrite was found in a part of the quarry not far distant from the spot where are found the beautiful white

[1] Arzruni, Zeitschrift für Ethnologie, 1884, p. 300.

grossular garnets, of rare occurrence, for which Jordansmühl is famous, and immediately adjacent to the masses of quartzite already mentioned, which may be a fused sandstone resembling in character the red and chocolate-colored rock found at Sioux Falls, Dakota, and a similar ornamental stone found in Norway and generally sold as Norwegian porphyry."

Among the rock and minerals collected in the quarry by Mr. Kunz were serpentine, granulite (quartz-zoisite rock), weisstein (quartz-zoisite rock), altered magnesia-silicate rock, altered actinolite-schist, hornblende rock with white and green spots resembling nephrite, actinolite with serpentine, kaolin, hyalite or hornblende-zoisite rock, and loess.

Professor Ernst Weinschenk of Munich has favored us with the following interesting and suggestive account of the occurrence of nephrite near Jordansmühl, the result of a visit to the locality and studies made on the spot:

"As is usually the case with this mineral, the nephrite of Jordansmühl is found in a serpentine of peridotite origin. Remains of this original peridotite are rare, but the reticulated structure of the serpentine, which is often very beautiful, leaves no doubt as to its origin. In addition, all the other forms of structure of serpentine are found side by side near Jordansmühl, while, finally, the general presence of chromite also points to an original peridotite. The rock is also very rich in other accessory minerals, notably actinolite, clinozoisite, grossularite, chlorite, and a mineral resembling mica, all of them, however, probably of secondary origin with the serpentine. These minerals occur partly in isolated, irregular beds, or are distributed equally throughout the rock, which also often contains patches of these accessory silicates, mostly of the actinolite, either in rather coarsely radiated aggregates, or, on the other hand, so compact of structure as to be designated nephrite. Even in the purest specimens, as is probably invariably the case, there is a slight admixture of chlorite and of isolated particles of the other silicates. The concretions of the latter present an analogous appearance.

"The form of the occurrence of all these silicates in the serpentine varies greatly. First of all, there intervenes between them and the serpentine a thin layer of a mineral resembling aplite, which, on the side nearest the serpentine, becomes considerably modified, growing especially rich in clinozoisite. The silicates form, further, roundish masses, generally of small size, in the serpentine itself, and finally occur as lighter veins and beds in the dark serpentine. But it is nearly always found that they are not in direct contact with the serpentine itself, a rather soft substance which under the microscope is found to be rich in chlorite, intruding and forming the transition to the normal serpentine.

"The occurrences at Jordansmühl have many points of resemblance to the serpentines of the most widely separated localities, but it must be observed that the formation of nephrite, which is here of comparatively frequent occurrence and has made the region famous, is elsewhere of minor importance. However, a comparison with other structures of the kind will lead to important conclusions regarding the origin of nephrite and of the minerals that occur with it.

"The peridotites, which nearly always contain a small amount of pyroxene, are distinguished by uncommonly numerous aggregates of that mineral, forming larger or smaller spots or knobs, occurrences which indicate that in the fluid mass of which the peridotite was formed there originated, through chemical action, cracks in which the pyroxene gathered.

"In other localities such separations within the peridotite, which is otherwise free of feldspar, contain a high percentage of plagioclase, while the composition of the spots is that of gabbro free from feldspar. When the peridotite changes to serpentine, these spots are partly preserved in their entirety (we know of many such occurrences in a fresh state in numerous serpentine formations), or they are subjected to radical changes, in which, according to their original difference in composition from the mass, the results of these changes remain distinct from it. In this case the pyroxene usually turns into aggregates of hornblende, 'uralite'; the feldspar, into compact masses of different kinds of alumina-lime silicates, which we call 'saussurite.' According to the nature of the original composition, one or the other of these two groups of minerals predominates. With all this, the structure is either retained or completely destroyed; but in thin sections of even the purest nephrite of this origin, its pseudomorphic nature can nearly always be clearly discerned.

"Similar changes in composition are found in the edge-zones of staffs of serpentine, the aggregation of actinolite in the edge-zones of the serpentines of the central Alps being notably characteristic. But there the aggregates are usually rather coarse in structure, whereas near Jordansmühl nephrite takes their place. Finally, the Alpine serpentines also usually have veins in which the same silicates have been formed. But these veins are of more recent date than the serpentinization of the peridotite, and are probably ascribable to the influence of thermal waters. They are distinguished chiefly by the fact that from both their walls outward the serpentine has been metamorphosed into a very compact aggregate of those minerals which in coarser form fill the veins. Here, too, one can often find traces of the original composition of the mineral in the compact parts of the thin section. This can practically never be done in the central group of occurrence.

"Near Jordansmühl are found together the three different processes which can lead to the formation of nephrite—(1) separations within the original peridotite, which later on becomes uralitic; (2) chemical modifications of the mineral at the zones of contact, partly based upon the original composition of the rock, and partly produced only by solutions active in the formation of serpentine; and (3) totally new formations, which gradually influence the surrounding rock. It is this that gives additional interest to the Jordansmühl occurrence of nephrite."

Reichenstein

In 1887 Traube announced the discovery by himself of another locality of nephrite *in situ*, at Reichenstein in Silesia. In his paper[1] he gives the following details:

"The arsenical ores of this locality are found, not only in serpentine and serpentine-bearing limestone, but also in strata which consist essentially of diopside, but which carry also tremolite and chlorite. The grayish-green to greenish-white diopside is often very coarse and broad-fibred, the irregular crystals of which are not infrequently ten centimetres long, showing good prismatic cleavage and parting parallel to the base. It also forms fine-grained to compact masses, whose mineralogical composition can scarcely be made out with the naked eye. In its prismatic development the diopside frequently shows alteration to coarse-fibred, light-green tremolite. The frequency of this transformation of the diopside into fibrous hornblende had already led me to believe that nephrite must occur here. But of all the specimens which were examined for this purpose, of which the Mineralogical Museum at Breslau possesses a large number, a few indeed appeared nephritic, in consequence of a finely fibrous structure, but none of them showed that finely felted structure under the microscope which is so characteristic of nephrite, and to which it owes its toughness.

"During a visit to Reichenstein last year I took out of the material hauled up at the Fürstenstolle (Prince's Mine) a large specimen which showed clearly the characters of nephrite in all respects. This was confirmed by Arzruni of Aachen, to whom I sent a piece for examination.

"This Reichenstein nephrite, which forms a layer about seven centimetres thick in the diopside rock, shows a bright grayish-green color, resembling that of the southern Siberian localities, in places with a reddish tinge, a very imperfect foliation, and the characteristic splintery, dusty-looking fracture on freshly broken surfaces. In general, the nephrite is perfectly compact and fibrous only in a few places, while at the borders, where it was originally in contact with the surrounding rock, it shows the beginnings of serpentinization. It contains only very little arsenical pyrites, and in places is quite free from this."

This identification as nephrite was fully confirmed by the microscopic and chemical examination. The author ends his note with the significant remark: "Although the Reichenstein nephrite has never been worked, yet the new find, which has been made at a much-visited locality, and one which has been often investigated mineralogically and geologically, shows how easily it may be overlooked, and also indicates the probability that it occurs *in situ* at a greater or less distance from the localities where it is met with in a worked state." This nephrite is represented in the Collection by Nos. 144, a piece of a pale-green color, and 147, of a darker green and thickly sprinkled with crystals of arsenopyrite.

Apart from these two localities nephrite has never been found *in situ* in Europe, though it is very prob-

[1] H. Traube, Neues Jahrbuch, 1887, II, 275–278.

able that it will eventually be discovered among the metamorphic regions. Of boulders of nephrite the following may be mentioned:

The discovery of a block of nephrite in the sands of Potsdam was reported by Prince Galitzin as far back as 1794. This was investigated by Fischer[1] and by Arzruni[2] and shown to be green nephrite. A second find was that described by Breithaupt[3] in 1815, of a smooth polished block of stone, which was found in the peat-bog of Schwemsal, near Düben in Prussian Saxony. This was shown by Breithaupt to be nephrite, and was subsequently investigated by Von Fellenberg,[4] Fischer,[5] and Arzruni.[6] A piece of it is No. 148 of the Collection. A third early find is that of the Leipzig specimen, found in a peat-hole near Leipzig, and first mentioned and analyzed by Rammelsberg[7] in 1844. This was also briefly described by Fischer[8] and Arzruni.[9]

It was suggested by Fischer[10] and others that these specimens had been brought by early man from Siberia or Turkistan and accidentally lost. The necessity for this hypothesis has been done away with by the discoveries of Traube already noticed, and it was vigorously opposed by Credner[11] on geological grounds. He points out that:

1. The three localities lie in the region of the North German diluvium.
2. The three specimens were all taken from glacial deposits.
3. The three localities lie in a zone which corresponds exactly with the direction of transportation of glacial material from Sweden through the North German Plain toward the elevated part of Saxony.

He argues that: "On the basis of all investigations in North German glacial deposits, it would be accepted without question for any other stone so found, that it was erratic and had originated in Sweden and had been transported to Germany by the ice. This is disputed in the case of nephrite on the grounds that: (1) no occurrence of nephrite is known in Sweden; (2) on account of the great petrographical resemblance between the German blocks and the nephrite of Siberia. These facts cannot be denied, but they lack force. The geological knowledge of Sweden is so incomplete that it is impossible to determine the exact place of origin of many of the boulders found in the North German diluvium, and yet no geologist hesitates to attribute them to Sweden. The petrographic argument is likewise of little value." Credner also points out that Sweden offers the same geological conditions which are associated with the occurrence of nephrite elsewhere: namely, the presence of gneiss and hornblende schists.

Additional specimens of nephrite occurring as boulders have been found in Styria, Austria. With the doubtful exception of one from the valley of the Sann, these all come from the valley of the Mur River, on which the town of Gratz is situated.

The first of these is said to have been found in 1880 at the Sann bridge, one hour's journey from the village of St. Peter.[12] It is a light leek-green, and resembles the *Kawakawa* of New Zealand. Five other boulders or pebbles have been found at Gratz, either in the bed of the Mur, or in rubble derived from this within the town limits.[13] These resemble very closely that from the Sann River,—so much so that there is scarcely a doubt that this also comes from the valley of the Mur, as Berwerth suggests. Berwerth also remarks: "since it has been demonstrated that nephrite boulders of a particular type occur in the Mur River region, we may confidently expect the discovery there of nephrite *in situ*. The mineral will be found probably in very thin layers or flat pieces in the mountains of metamorphic schists."

Down to the present time no true jadeite has been discovered *in situ* in Europe. Penfield[14] has described a massive jadeite-like mineral from St. Marcel in Piedmont, which apparently occurs *in situ*. It is described as "an interwoven aggregate of prismatic crystals, resembling in structure a rather coarse jadeite. The material is very tough, and the color a sort of ash-gray." The specific gravity varied from 3.257 to 3.382, and the analysis resembled those of other jadeites. Boulders of this had been previously found at the local-

[1] Fischer, Jadeit und Nephrit, pp. 2, 156, 157.
[2] Arzruni, Zeitschrift für Krystallographie, 1885, p. 540.
[3] Breithaupt, Handbuch von C. A. S. Hoffmann, 1815, II, 254.
[4] Von Fellenberg, Verh. d. Schweiz. Ges. in Solothurn, Aug., 1869.
[5] Fischer, op. cit., p. 253.
[6] Arzruni, Zeitschrift für Krystallographie, 1885, p. 540.
[7] Rammelsberg, Pogg. Ann., 1844, LXII, 148.
[8] Fischer, op. cit., p. 217.
[9] Zeitschrift für Krystallographie, 1885, p. 540.
[10] Fischer, Neues Jahrbuch, 1881, I, 196 ff.
[11] Credner, Neues Jahrbuch, 1884, II, 235, ref.
[12] Meyer, Abhand. Naturw. Ges. Isis in Dresden, 1883, p. 77.
[13] Meyer, Mitth. Anthrop. Ges. (Wien, 1883), XIII, 216; Berwerth, Ann. Hofmus. (Wien, 1888), III, 79; Berwerth, Ann. Hofmus. (Wien, 1899), XIII, 115; Meyer, Das Globus, May 6, 1899, LXXV.
[14] Penfield, Amer. Jour. Sci. (4), 1893, XLVI, 291.

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No. 705

LARGE BOWL AND COVER

(*Ta Kai Wan*)

Chia-ch'ing to Tao-kuang (1796–1850)

Nephrite


Émile Sulpis

ity, and were analyzed by Damour,[1] who also analyzed a jadeite[2] forming a small vein in quartzite at St. Marcel. It is of interest to note that glaucophane-schists are found in this region, recalling the similar occurrence at Tammaw in Burma. Another specimen is described by Damour[3] as having come from Monte Viso in Piedmont. There has been much discussion about this piece, but there seems to be no reason for doubting that it is a true jadeite and comes from this region. Meyer[4] reports the finding of two boulders of jadeite on the shores of Lake Neuenburg, canton of Freiburg, Switzerland. They are green and resemble the material of some of the Swiss stone implements. A pebble found by Damour[5] at Ouchy, near Lausanne, on the shore of Lake Geneva, is also undoubtedly true jadeite.

NORTH AMERICA

Dr. G. P. Merrill, of the United States National Museum, has written a paper on the occurrence of jade in America for Mr. Bishop, which has been used in the following pages.

Alaska

"Various aboriginal objects, principally hammers, cutting implements, and small ornaments, made of nephrite and jadeite from the western coast of America, have been known to archæologists for many years, but it is only recently that the exact source from which any of the material was derived has been discovered.

"The late Professor S. F. Baird, who took a great interest in the source of these materials, urged Lieutenant G. M. Stoney, who in 1884 was preparing to explore the Kowak River of Alaska, to make a special effort to ascertain whence this material comes, and to obtain specimens."

Lieutenant Stoney discovered the locality, the so-called Jade Mountain, about 150 miles above the mouth of the Kowak River, in latitude 67° 05′ north and longitude 158° 15′ west. The mountain is described by Stoney as being bright green in color and from 1000 to 1500 feet high.

The material brought back by Stoney in 1884 was shown by Merrill[6] to be serpentine, but on his second visit he secured true nephrite. Stoney, unfortunately, does not describe the geology of the occurrence, but merely speaks of the occurrence of shale and serpentine along with the jade, and states that the latter crops out on the surface.

This locality is probably identical with that spoken of by E. W. Nelson[7] as the source of the material of the jade implements in use by the Innuits of Kotzebue Sound, and which they all declared came from a steep hill ascending from one of the rivers. Nelson also mentions jade celts in use among the Indians of the Yukon about Nulato, the rough material of which they claim is found upon the side of a mountain about twenty-five miles from Nulato. He also states, on the authority of the natives, that jade occurs in the mountains on the western part of the Kaviak Peninsula near Bering Strait. There are also indications that it is found near Bristol Bay. Nelson speaks of a few jade fragments being seen by him on the Siberian shore of Bering Strait, but was informed that they came from the American side.

Specimens of the jade brought back by Stoney, as well as numerous implements from Alaska, have been examined by Clarke and Merrill[8] and shown to be true nephrite, closely resembling that of Siberia, New Zealand, and some of the lake-dwellings in Switzerland.

In this connection it must be mentioned that the Collection contains a large pebble of nephrite (No. 157) from Sulphur Creek, a tributary of Indian River, about forty miles from Dawson.

British Columbia

In 1887 Dr. G. M. Dawson[9] announced the finding at Lytton and Yale, on the lower part of the Fraser River, in British Columbia, of two partially worked nephrite boulders of such a nature as to show that they had

[1] Damour, Bull. Soc. Min. France, 1881, IV, 161.
[2] Damour, Comptes Rendus, 1881, XCII, 1313.
[3] Damour, Comptes Rendus, 1881, XCII, 1312.
[4] Meyer, Antiqua. Zürich, 1884; cf. Neu. Jahrb., 1885, II, 6.
[5] Damour, Bull. Soc. Min. France, 1881, IV, 161.
[6] Merrill, Science, March 13, 1885.
[7] E. W. Nelson, Letter to Professor Baird, Proc. U. S. Nat. Museum, 1883, VI, 426.
[8] Clarke and Merrill, Proc. U. S. Nat. Museum, 1888, p. 115.
[9] Canadian Record of Science, 1886–87, II, 364.

been derived from the immediate banks of the river, where they had been doubtless deposited by the river itself. This material was studied by Professor B. J. Harrington[1] and shown to be a true nephrite, and partially identical with that of Alaska. A number of jade celts from graves near Lytton have lately been examined by Professor J. F. Kemp[2] and shown to be nephrite. Outcrops of this are said to occur "in a creek tributary to the Fraser River some miles above Lytton."

Boulders of nephrite have also been found by Dr. Dawson[3] and Mr. Ogilvie on the upper Lewes River, near the Alaskan boundary. Dr. Dawson says: "Though not actually observed in place, the material is evidently derived from the altered (metamorphosed) volcanic rocks, probably of palæozoic age, which are abundant in the district." It is also reported that nephrite has been found in Miles Cañon and at the Kwikpak mouth of the Yukon.[4]

NEW ZEALAND

The first notice of the occurrence of jade in New Zealand is in 1774,[5] when Hawksworth speaks of the natives using for axes and planes a "green, talc-like stone, which is not only hard but also tough."

The next author to mention it is J. R. Foster,[6] who says that, according to the unanimous testimony of the natives, it occurs "beyond the inner part of Charlotte Sound, towards the south-west." He also states that he found the rock at the small island of Motuaro, in "dykes," some two inches thick, partly vertical and partly oblique, in a mountain of gray talcose rock.

The occurrence of nephrite, which the natives call *pounamu*, in New Zealand, is described rather meagrely by Von Hochstetter,[7] from whose paper the following extracts are taken:

"All New Zealand nephrite comes from the west coast of South Island, where it is found partly *in situ*, but mostly in the form of boulders and rolled masses in river beds and on the sea-shore. No nephrite is found on the east side of the South Island, or on the North Island. The South is called Te Wahi Pounamu: *i. e.*, Jadeland, or the region of jade.[8]

"But little is known thus far regarding the occurrence of the mineral *in situ*. The information given by the natives and others indicates that there are three principal places where *pounamu* is found.

"The first is situated on the Arahaura or Brunner River, about fifteen miles from its mouth. The natives say that the nephrite projects from the river bed, several feet thick, in the form of an overturned canoe, standing upright. They therefore call the locality Te Whaka (The Canoe). The rock is said to be so hard and compact that they cannot break it, but must content themselves with pieces which they find in the river and on the sea-shore. The natives describe the country-rock as a green schist, probably talcose or chlorite schist or serpentine.

"A second locality lies south of Mount Cook in the neighborhood of Jackson's Bay, or on Milford Sound.

"Dr. Hector, the geologist of the Province of Otago, who investigated Milford Sound during an expedition to the west coast, says in his report[9] regarding the occurrence at Milford Sound: 'We anchored for a short time in Anita Bay (by Milford Sound), for the purpose of examining the shore whence the Maoris obtain jade or greenstone for their ornaments and weapons. This rock is found among the beach pebbles in rolled pieces, together with pieces of hornblende-gneiss and felsite. Although I found many boulders of jade, I could not discover the original place whence they were derived. But a thick dyke of felsite crops out back of the shore, in contact with green hornblende-rock and serpentine, and since the felsite near the corner of the dyke contains green grains with the characters of this mineral, it is probable that the jade has been formed in nodules and irregular masses along the contact.'[10]

"A third locality is said to be Lake Pounamu, in Otago Province, which is identical with that given on the maps as Lake Wakatip.

[1] Harrington, Trans. Roy. Soc. Canada, 1890, Sec. III, p. 61.
[2] Kemp, Mem. Acad. Mus. Nat. Hist., 1899, II, Anthrop, I, 132–133.
[3] Dawson, Science, 1888, XI, 186.
[4] Dana, System of Mineralogy, 1899, p. 397.
[5] Cf. Fischer, op. cit., p. 134.
[6] Cf. Fischer, op. cit., p. 135.
[7] Von Hochstetter, Sitzber. Akad. Wiss. (Wien, 1864), XLIX, 466–480.
[8] Von Hochstetter here refers to the island usually designated "the Middle Island"; the South Island proper is Stewart Island.—EDITOR.
[9] Geological Expedition to the West Coast of Otago, Provincial Government Gazette, 1863, p. 460.
[10] Chapman (Trans. N. Z. Inst., 1891, XXIV, 525) says of Hector's search: "He failed to find the dyke, which was my experience thirteen years later, but I am now informed that it is higher up the shore."

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No. 160
SMALL BROKEN SLAB

No. 166
SMALL THIN SLAB

No. 159
THIN SLAB

No. 162
FRAGMENT OF BOULDER

NEW ZEALAND NEPHRITE

"Some pebbles and boulders of nephrite are found along the whole west coast from Cape Foulwind on the north as far as beyond Milford Sound to the south. I myself found a small knobby, unrolled piece, three inches in diameter, among the pebbles on the shore of Current Basin, north of Nelson, where a thick bed of serpentine (the serpentine of Dun Mountain) occurs, accompanied by various schists; *i. e.*, in the same geological conditions as those described by Dr. Hector at Milford Sound, where also serpentine occurs in the vicinity."

Von Haast[1] says: "Nephrite is also found in the gneiss-granite formation on the west coast in Greenstone Creek, the Arahaura, and some other localities. I have never observed it *in situ*, but the Canterbury Museum possesses a specimen of nephrite to which a small portion of the bed-rock, chlorite schist, is still attached."

Of the Milford Sound locality Ulrich[2] says: "It is a narrow boulder bank at the foot of a mountain, overgrown with crowded shrubs, and which is accessible only to the Maoris. The massive rock seems to be a syenite, and nephrite probably occurs in small veins or pockets high up on the slope."

NEW CALEDONIA

Axes from New Caledonia have been known for a long time. They are green in color, and are apparently of nephrite. This occurs *in situ* on the west coast of the Island of Uen, off the southeastern point of New Caledonia, and probably elsewhere.[3] The occurrence has been described by Garnier.[4]

"The euphotides (gabbros) of the Koutoure Bay region differ in appearance. They pass into diorites with large feldspar and hornblende crystals. Toward Nogouneto one finds rocks of a beautiful green, translucent at the edges, with a somewhat greasy lustre and a splintery fracture, but still retaining, notwithstanding this changed appearance, the greenish, foliated aspect of the euphotide in some parts of its beds. It is easily seen that the beds of these different rocks are unconformable.

"These new beds are only slightly homogeneous in composition. Certain parts, compact and green, are of about the hardness of glass; others, on the contrary, are very soft. Their structure is schistose, with very thin undulating white or green scales, like serpentine. This rock occurs here in conjunction with serpentine schists, veins of impure quartz, and compact feldspar. This fine white stone, with green veins, easily fusible before the blowpipe, has many of the characters of hatchet jade."

The varieties distinguished by the natives are very numerous, and are only true nephrite in part, some being undoubtedly serpentine. They have been described at some length by Von Hochstetter[5] and Rev. J. W. Stack.[6]

WORKED OBJECTS AND UNCERTAIN LOCALITIES

It would be out of place here to give a list of all the localities where worked objects of jade have been found. The catalogue of the Collection is sufficient evidence of their number and variety, and gives a practically complete list. An attempt will be made to indicate only those cases which may have a bearing on the main subject of this paper, viz., the geological occurrence of jade.

Apart from China, a large number of jade objects have been found in Asia. The most noteworthy is the huge monolith of dark-green nephrite which is placed on the tomb of Timur in the Gur-Emir mosque at Samarkand, and represented in the Collection by the fragment numbered 77. The provenance of the material is as yet unknown. Schoetensack[7] describes a dark-green nephrite disc from Manas, on the north slope of the T'ian Shan range, and remarks on its resemblance to the nephrite of the Samarkand block. A good-sized boulder, with traces of lacquer and gilding, is in the Collection (No. 78). It is said to have come from Manas or Barkul, and was obtained by Dr. S. W. Bushell in Peking.

Tibet is said also to be a locality for jade, though there is some doubt on this point. It is very probable

[1] Von Haast, Geology of the Provinces of Canterbury and Westland (Christchurch, 1879), p. 255.
[2] Cf. Fischer, Mitth. Anthr. Ges. (Wien, 1879), VIII, 166.
[3] Cf. Meyer, Jadeit und Nephrit Objecte, Part III, pp. 53 ff.
[4] Quoted in Meyer, op. cit., p. 56.
[5] Von Hochstetter, op. cit., pp. 469–475.
[6] Cf. Chapman, Trans. N. Z. Institute, 1891, XXIV, 513.
[7] Schoetensack, Inaug. Diss. Freiburg (Berlin, 1885), p. 2.

that by "Tibet" is meant Little Tibet, or Baltistan, which lies northwest of Cashmere and southwest of, and not far from, Khotan, near the Karakorum Mountains. The large size of the blocks said to have been brought from Tibet by certain well-known travellers would seem to exclude Tibet proper.

Schoetensack examined a specimen said to have come from Tibet, and showed that it closely resembled typical Burmese material. Fischer,[1] Cohen,[2] and Bauer[3] also describe jadeites from this region, and there are several specimens in the Collection. According to Bauer, the "Tibetan" jadeite closely resembles that of Tammaw in Burma, showing also the same cataclastic structure. Its most striking feature is the presence of nephelite, a small amount of albite being also visible. The bearing of this on the question of the origin of jadeite has already been discussed in this work by Professor Pirsson.

At Schliemann's excavations at the site of Troy in Asia Minor, a number of hatchets, both of nephrite and jadeite, were found. A hatchet and a cylinder from Mesopotamia have also been reported, as well as a jadeite hatchet from Sardis in Asia Minor. A small number of worked jade objects have also come from Japan, but probably in the course of commerce from China, as we have the explicit statement of Mr. Wada, formerly professor of mineralogy at the University of Tokio and ex-director-general of the Geological Survey of Japan, that jade is not found in that country.

In Europe very many objects have been found both of nephrite and jadeite. Implements of nephrite have been found in abundance in the ancient lake-villages of Switzerland, as for instance at Lakes Constance, Zürich, Neuchâtel, and Pfäffikon. These are usually of a dark leek-green color and foliated structure. Very few nephrite implements have been found north of Switzerland. A few have been found in Belgium, and a few in Germany. Three have been reported from France, some from Italy (chiefly Calabria), and one or two from Greece. It is seen, therefore, that the nephrite objects of Europe are almost exclusively confined to the Swiss localities.

Objects of jadeite are much more widely distributed, and may be broadly divided into the large flat celts of northwestern Germany, France (especially Morbihan), and Belgium, and the small polished celts of western Switzerland, Italy, and the Rhine Valley of southern Germany. In the lake-villages, on the contrary, jadeite implements are comparatively rare. S. Franchi[4] reports objects of neolithic station of Alba, discovered by G. B. Traverso in 1892. Some were rough pieces and pebbles, others partly worked, others still fragments of axes, celts, etc., of good workmanship. Of these two are of lherzolite, one of talc-schist, others of eclogite, and others of a jadeite rock, from light to dark green. These are composed of a greenish pyroxene which seems to be jadeite, with garnet and glaucophane; the darker ones carry chloromelanite. Jadeitic rocks occur with eclogite in the basins of the Po and of the Vavita, "along with glaucophane-schists, both *in situ* and as blocks." Chloromelanite occurs at Mocchio, Val di Susa. It is light grass-green, compact and fibrous, with silky lustre. Specific gravity, 3.33. Fuses easily before the blowpipe. Under the microscope, composed of a bluish-green monoclinic pyroxene, with extinction angle of 35° to 39°, pleochroic, partly uralitized. The pyroxenes are not more than 0.1 millimetre long. As accessory minerals occur garnet, a little ilmenite, rutile, and pyrite. Jadeite from lakes of Prato Fiorito. Light emerald-green, fine-grained structure. Hardness, 6–7; specific gravity, 3.34. Fuses easily before the blowpipe, coloring flames yellow. Under the microscope, colorless granular structure, elements not fibrous.

In America, as has been already said, the only localities for nephrite are Alaska and British Columbia. It may be added that Meyer[5] mentions the finding of a piece of rough jadeite in Louisiana, though, from the known geological features of this State, it must have been brought from a distance.

It is not known to me whether any nephrite or jadeite objects have been found in the western parts of the United States, though it may be mentioned here that some of the conditions in California would seem to be favorable for the discovery of jadeite there.

In Mexico, soon after its discovery, the Spaniards became acquainted with a hard green stone highly valued by the natives and called by them *chalchihuitl*. Although a number of different substances were probably embraced under this head, yet the large number of objects of jade which have been found in Mexico

[1] Fischer, Jadeit und Nephrit, p. 235.
[2] Cohen, Neues Jahrb. für Min., 1884, I, 71.
[3] Bauer, Neues Jahrb. für Min., 1896, I, 85.
[4] Sopra alcuni giacimenti di roccie giadoitiche neile Alpi Occidentali e nell' Appennino Ligure, Bulletino R. Comitato Geologico d'Italia, 1900, XXXI, 119.
[5] Meyer, Das Ausland, June 4, 1883.

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LOTUS VASE

(Lien-hua P'ing)

K'ang-hsi (1662–1722)

Nephrite

proves that the ancient inhabitants were acquainted with this material. These objects have been examined by a number of authorities,[1] and are in general of jadeite, though a few seem to be of nephrite. Most of them come from the state of Oaxaca.

Central America also furnishes jadeite which closely resembles that of Mexico. Specimens investigated by Clarke and Merrill[2] come from Costa Rica, Nicaragua, and Guatemala. Those from Costa Rica are not only the most numerous, but also the finest.

Pebbles of a green, opaque, jade-like stone, capable of a very fine polish, are said to be found on the beach at Port Royal, Jamaica.[3] These are said to be the same stone out of which the Indians made their hatchets.

Several celts and an idol are reported by Fischer and Meyer as coming from various islands of the West Indies, but their real provenance seems to be uncertain.

From South America celts and other objects have been described by Fischer and Meyer. They come from a few localities in Colombia, Venezuela, and Brazil, and are all of nephrite. A green stone, called Amazon-stone, is mentioned by several writers, as far back as Buffon and Humboldt, as coming from Guiana and Brazil, but its nature is uncertain. An olive-green jade is also stated to have been found on the sea-coast of Peru by La Condamine.[4] A stone axe brought by Humboldt from Peru was thought by Fischer[5] to be probably jadeite.

From New Guinea (Papua) a number of axes of jadeite and chloromelanite have been described. Whether the raw material is derived from that island or not is not known. It is of interest to note, however, that chlorite-schists have been noticed at Humboldt Bay,[6] so that it seems possible that they are of native origin.

Implements and ornaments of jade have been reported from Java, Otaheite, the Marquesas, New Hebrides, and elsewhere in the Pacific, but of their occurrence and real provenance practically nothing is known. The same is true of the few objects reported from various parts of Africa.

GENERAL DISCUSSION

Distribution of Jade

From the facts regarding the occurrence of jade set forth in the preceding pages we may draw the following conclusions as to its distribution:

In the first place, it is evident that neither nephrite nor jadeite is of common occurrence. This is especially true of jadeite. So far as known at present, nephrite occurs *in situ* only in the K'un Lun Mountains, Central Siberia, Silesia, Alaska, New Zealand, and New Caledonia, and perhaps India; while localities, indicated by boulders and worked objects found, probably remain to be discovered in Sweden and elsewhere in Europe, as well as in China, the T'ian Shan Mountains, and other points in Asia. Jadeite has so far been found *in situ* in Burma only, though possibly also in India and Little Tibet, and jadeite-like rocks occur in Piedmont, while worked objects point to localities in Mexico and Central America, New Guinea, and Europe. It is decidedly unfortunate that all of these known localities, with the exception of Silesia, are in regions difficult of access, and in which the geological conditions are comparatively little known.

A second conclusion is that nephrite and jadeite are, as a rule, found to occur independently of each other in separate localities. It is true that there are exceptions. Some of the sections examined by Iddings and already described in this volume, as well as the chemical analyses, show the presence of both minerals in the same specimen. Schoetensack[7] describes specimens, brought from Turkistan by Von Schlagintweit, which consist partly of jadeite and partly of nephrite; Bauer[8] speaks of "jadeite embedded with nephrite in the crystalline schists of Turkistan"; and other instances might be given.

[1] Damour, Comptes Rendus, 1881, XCII, 1312; Meyer, Jadeit und Nephrit Objecte; Clarke and Merrill, Proc. U. S. Nat. Mus., 1888, p. 121; Arzruni, Zeit. für Kryst., 1885, p. 540.
[2] Clarke and Merrill, op. cit., p. 124.
[3] Natural History of Jamaica, by Sir Hans Sloane, 1820.
[4] Buffon, Hist. Nat. des Min., 1798, IV, 17.
[5] Fischer, op. cit., p. 166.
[6] Meyer, Jadeit und Nephrit Objecte, pp. 51 ff.
[7] Schoetensack, op. cit., p. 8.
[8] Bauer, op. cit., p. 104. He refers possibly to Schoetensack's observations.

These facts are of great interest as forming the basis of Iddings's theory that nephrite is sometimes derived from jadeite by secondary metamorphic processes of uralitization and chemical replacement. But the general statement remains true that at certain localities nephrite predominates to the total, or almost total, exclusion of jadeite, while elsewhere exactly the reverse holds good, jadeite being found alone or with only very subordinate amounts of nephrite.

The third conclusion to be drawn is, that, as compared with nephrite, jadeite is of very rare occurrence, that is, *in situ*. This is not only of great interest from an artistic and archæological standpoint, but is closely connected, as we shall see, with the question of the origin of the two minerals.

Geological Conditions of Occurrence

Though the occurrences of jade are few and not yet, in most cases, satisfactorily investigated, yet we are not left in much doubt as to the general character of the geological conditions. The testimony of the observations, both in the field and with the microscope, is unanimously in favor of the view that both nephrite and jadeite belong to the series of crystalline schists. That is, they owe their present characters to changes induced in the original rock bodies through pressure, heat, etc., consequent on crustal movements, these changes being known collectively as metamorphic. This is a fact universally recognized by petrographers, as is shown by the position assigned them in all the petrographic works dealing with the subject.

For the petrographic details which lead us to this conclusion the reader must be referred to the papers of Iddings and Pirsson in this volume, to those of Arzruni, Bauer, Traube, Clarke and Merrill, and others cited in the preceding pages, and to standard works on rocks, such as those of Zirkel and Rosenbusch.

The geological evidence is set forth in the preceding pages, but it may be of use to summarize and make a few remarks on the various occurrences.

As regards the Tammaw (Burma) occurrence, Noetling is in some doubt as to its character. Bauer's evidence, however, is sufficient to remove these doubts, which are largely due to the difficulties of observation in that region, and to assure us that the rock belongs to a metamorphic complex, and occurs in connection with serpentine of a metamorphic character. Attention must again be called to the presence here of glaucophane-schist and a hornblende-albite rock, the importance of which will be brought out subsequently.

The evidence as to the jade occurrences at Rewa in India is also conclusive. While there is doubt as to whether the jade here is a nephrite or jadeite, yet the association at the hill-section at Pipra is undeniably of a metamorphic character, and these localities are all in a region of gneiss. The important feature of the occurrence of corundum with the jade must be recalled.

The observers to whom we are indebted for our knowledge of the Turkistan localities—Von Schlagintweit, Cayley, and Stoliczka—differ, it is true, in certain small details. These discrepancies may be explained by the hurried nature of their observations and by the absence of petrographic and mineralogical study of the materials.[1] In the main, however, and in the essential features, they are all very closely in accord; and their observations prove conclusively that the jade is part of an extensive metamorphic complex, associated with gneiss and mica and amphibole schists.[2]

The observations of Jaczewski in the Sayan Mountains in Siberia show conclusively that the nephrite occurs in a region of argillaceous and actinolite schists, and in association with serpentine, magnetite, and graphite. In fact, this author states definitely that the actinolite schists have been changed into nephrite. It would be of very great interest to have a more detailed account of this occurrence.

The observations and descriptions of Traube establish clearly and in great detail the passage of gneiss and other rocks into nephrite, in an area which is metamorphic. It may also be mentioned that the probable derivation of the German boulders from the metamorphic rocks of Scandinavia is urged with great force by Credner.

The New Zealand, New Caledonian, Alaskan, and British Columbian occurrences are, unfortunately, of

[1] Cf. Beck and Muschketow, op. cit., p. 70.

[2] The observations and more recent petrographic knowledge of Stoliczka seem to show that the "greenstones" of Von Schlagintweit are really amphibole schists, and not igneous diorite.

little use, owing to the paucity of details, but the few which are given serve to strengthen the view that the nephrite here is of metamorphic origin.

The Collection furnishes very good examples which illustrate the metamorphic character of these rocks. In the majority of the worked pieces this is not evident to the naked eye, being visible only in thin section under the microscope, but the large cylindrical brush-holder No. 679 shows traces of a schistose structure. Certain of the "tomb pieces" (*e. g.*, Nos. 316 and 332) show clearly a streaked mixture of colors, closely approaching that produced by shearing forces.

A very distinct and well-marked schistosity is, however, shown by many of the archæological pieces (*e. g.*, Nos. 184, 192, 193, 198, 287), where the schistose structure has evidently been taken advantage of in fashioning the article. This structure is especially well brought out by weathering (Nos. 192, 193, 198).

The same structure is very clearly seen in many of the rough pieces (*e. g.*, Nos. 71, 141, 153, 155, 161), the last two especially (both from Alaska) exhibiting it very beautifully, both on the rough surfaces and on the polished faces, on the latter being seen the fine, wavy lines produced by cutting across the corrugations.

Discussion of the Origin of Jade

This subject has been already dealt with in this volume, by Pirsson and Iddings, but the facts brought out by the review of the geological occurrences lead me to make a few remarks on this topic. The metamorphic character of both species may be accepted without question. This is an important point gained, but only throws the question of their origin back one step. Before undergoing metamorphism what were they? Were they sedimentary or igneous rocks?

As far as jadeite is concerned, the clear and logical paper of Pirsson, together with the remarks of Iddings on this subject (both having been written independently of each other), can leave no doubt that jadeite is a metamorphosed soda-rich, igneous rock, originally a nepheline-syenite, a phonolite, or a tinguaite. This view has been so forcibly brought out by the two writers just mentioned that I need add nothing to their remarks on this point.

With nephrite, however, the case is quite different. In chemical composition it does not, like jadeite, resemble very closely any of the igneous rocks, being distinguished chiefly through its very low alumina; though there is much analogy in this respect with the websterite[1] of Maryland and North Carolina, which is an igneous diopside-bronzite rock with granitic structure. It also resembles, in general features, the pyroxenites, etc., though in these, as a rule, the content in alumina is much higher.

Arzruni, it will be recalled, divided the nephrites into primary nephrites and those derived from pyroxene by uralitization; by pyroxene meaning not jadeite, but diopside. Iddings shows that in many cases nephrite is undoubtedly derived from jadeite. He does not, however, deny that it may not be so derived, but may in some cases be the product of metamorphism of an original diopside or amphibole rock, itself igneous or metamorphic. In such a case it preserves essentially the *chemical* character of the rock which produced it.

Traube's descriptions leave little or no doubt that at the Silesian localities the nephrite is not derived from jadeite by metasomatism (the chemical interchange of matter), but that it is here derived from either an original pyroxene (diopside) rock, or partly, as far as can be judged, through the further metamorphism of an amphibolic rock. At the Indian localities and in Siberia the evidence goes to show that here also the nephrite is not derived from jadeite; since at both localities specific mention is made of hornblende rock passing into jade.

It is true that the chemical analyses of material from these localities, as well as from New Zealand and New Caledonia, show small amounts of soda, which, according to Clarke's reductions of the analyses, is present in molecules of glaucophane and riebeckite, the amounts of these being always very little. It is to be remembered, however, that soda is almost constantly present in igneous rocks, though sometimes to a very small extent, even in the pyroxenites and other basic rocks, so that its presence here is no valid argument for an origin from jadeite. In all these cases there seems to be little reason to invoke such a decided and complete interchange of substance as that involved in the change of jadeite into nephrite.

[1] G. H. Williams, Amer. Geol., 1890, VI, 42, 44.

At the K'un Lun localities, however, the case is different. Here the observations of Schoetensack and Iddings, as well as the chemical analyses, show that jadeite is present along with the nephrite; and the microscope showed Iddings that there really had been such a passage of one into the other. In fact, the best examples found by Iddings of a change of jadeite into nephrite are specimens from Turkistan and China, the material of the worked objects of which latter country being undoubtedly derived, at least in the greater number of instances, from Turkistan and Burma. In Burma, also, there is evidence that the jadeite has to a certain extent been changed into nephrite.

In this connection it is of interest to note that all the three observers of the K'un Lun quarries—Von Schlagintweit, Cayley, and Stoliczka—speak variously of an "altered" or a "soft, friable substance—evidently a product of decomposition by percolating water," "a white, powdery clay," or "veins of a pure white, apparently zeolitic mineral," appearing either between the nephrite and the schist or in close connection with it. A similar substance is also mentioned by Noetling as occurring at Tammaw along with the jadeite.

Now, in the replacement of alumina and soda by magnesia and lime, which is necessitated by the change of jadeite to nephrite, the two last would have been provided in abundance by the amphibolic schists and the serpentine. The alumina and soda would not entirely disappear, but traces of them should be met with somewhere. These white or light-colored bands, then, may reasonably be supposed to be derived from the replaced alumina and soda of the original jadeite. They may be zeolitic, as suggested by Stoliczka, in which case they might be largely natrolite, a hydrous silicate of soda and alumina; or they may be, and more probably are, chiefly one of the kaolins, hydrous silicates of alumina alone, the soda having been removed by solution. This is, of course, largely hypothetical, since we have no detailed chemical or mineralogical description of these bands, but the suggestion seems to be a reasonable one. It is to be remarked, in this connection, that there is no mention of the presence of such material at any of the three localities where the nephrite is evidently not derived from jadeite.

Having thus gained a general and probably fairly correct notion of the origin of jadeite and nephrite, one of the reasons for the rarity of their occurrence becomes evident. Leaving apart the metamorphic processes involved, of the exact nature of which for the production of the characteristic qualities of jade we are not yet in a position to speak, we can examine the matter from the point of view of the rocks from which jade is derived.

In regard to jadeite, the nepheline-syenites and phonolites from which it is derived are among the more rarely occurring of all the igneous rocks; so that its rarity naturally follows. Following the same line of argument, the occurrence of jadeite-derived nephrite would naturally be also rare, possibly even more so than jadeite. Igneous rocks from which nephrite could be derived without radical change of substance, such as the websterites, cortlandites, and other pyroxenites, hornblendites, or peridotites, are also rare, though occurring more frequently than the nepheline-syenite family. The amphibolites and other such schists are of extremely common occurrence. We would consequently expect to find nephrites more often than jadeites, and the fact that they are so found is, in a way, evidence that in the majority of cases nephrite is not derived from jadeite.

Probable Localities Elsewhere

While we are dealing with the localities of jade, it will probably be of value to those interested in jade to indicate where nephrite and jadeite may reasonably be expected to occur *in situ*, and to point out the rocks which are likely to occur in connection with them, and whose presence may indicate their possible discovery.

It may be stated with confidence that both are to be looked for *in situ* only in regions of crystalline schists, and more especially, perhaps, in regions of amphibole schists; though they are known to occur also in connection with gneiss and mica and chlorite schists.

Nephrite is undoubtedly far more abundant than jadeite, a point which has been already touched on, and it would naturally be looked for in regions where so-called basic rocks occur: *i. e.*, rocks high in iron, lime, and magnesia. On the hypothesis that it is ultimately derived from igneous rocks, we would expect to find

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No. 449

MOUNTAIN LANDSCAPE

(*Shan-tzŭ*)

K'ang-hsi (1662–1722)

Nephrite

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it in metamorphic regions where gabbros occur, as in Silesia, or regions where olivine rocks are found, as in New Zealand, or along with pyroxenites or hornblendites.

It would take up too much space to give a list of the localities of such rocks, and, furthermore, it seems probable that it will be found in quantity only in regions at present but little known. It must be confessed, however, that its discovery at Jordansmühl and Reichenstein shows that it may be found eventually at localities with which we are supposed to be well acquainted, as, for example, possibly the Adirondack region of New York State, and in North Carolina.

Jadeite, being derived from rocks of the nepheline-syenite family, will, as has already been pointed out, be much rarer than nephrite. If nepheline-syenites or ancient phonolites occur in metamorphic areas, and if their advent is prior to the general metamorphism, the occurrence of jadeite would be not unexpected.

There are, however, two additional facts of some interest to be noted here. In the first place, we have already seen that glaucophane-schists occur in connection with jadeite in Burma and Piedmont. Although this group of schists has been but little investigated, it seems probable that they are the result of the metamorphism of basic igneous rocks, of the general composition of gabbro, which are sometimes found in association with the family of the nepheline-syenites. These schists are of a peculiar blue color, often running into epidotic and garnetiferous rocks, so as to be usually easily recognizable, and their presence in any region would lead us to hope for the occurrence of jadeite *in situ*.

These peculiar schists are of very rare occurrence, and their chief localities may be mentioned. These are Syra and other islands of the Ægean Sea, together with various localities along the east coast of Greece; Île de Groix in Brittany (Morbihan),[1] Piedmont, Croatia, Corsica, and Andalusia; island of Shikokŭ, Japan; and in California.

The second point to be mentioned is a possible connection between the occurrence of corundum and jade. Corundum occurs as a primary constituent of various igneous rocks, in crystalline schists, and in limestones. The igneous rocks in which it occurs differ considerably. In some cases they are very basic, as the peridotites of North Carolina and the cortlandites, etc., of Peekskill, New York. But the rocks which are of especial interest to us here are the nepheline-syenites and other alkaline plutonic rocks. Such corundum-bearing rocks occur in the Urals,[2] in Ontario,[3] in India,[4] and elsewhere, though they are very rare.

A discussion of all these localities would lead us too far, and we need only note here that the soda-rich rocks are generally high in alumina and more or less apt to carry corundum, though its occurrence in them is as yet, and probably will always be, a great rarity. It follows, however, that corundum may be (but by no means necessarily is) an indication of the presence of soda-rich rocks, and hence, in metamorphic regions, of possible jadeite.

As an instance of such an association, we may note that south of the jade-mines of Tammaw in Burma corundum occurs as gem material in various localities, being found in a limestone which Judd has shown to be probably derived from an original igneous rock.[5] These rocks were basic, and are correlated by Holland with the corundum-bearing anorthite rock of the Salem district in Madras, and possibly with those of Ceylon. They seem to correspond closely to the corundum-anorthite "kyshtymites" of the Urals, recently described by Morozewicz in the paper already cited. These are high in lime, and are basic phases of rocks very rich in soda and alumina. Possibly, as suggested by Holland, the Rewa occurrences are of a similar character, in which case the jade would be a jadeite; though, as already noted, the probabilities seem to be in favor of its being nephrite, especially since corundum is known to occur in basic soda-free rocks.

It must be repeated that all the above is highly speculative, and is inserted chiefly as being of suggestive interest; but, from the facts given, the conclusion may be drawn that the occurrence of nepheline-syenites, glaucophane-schists, or corundum in metamorphic regions would suggest to the traveller the possible presence of jadeite. The hypothetical character of these remarks, however, emphasizes the extremely scanty

[1] The finding of worked jadeite and chloromelanite objects at Morbihan and Dordogne is very suggestive in this connection.
[2] Morozewicz, Tschermak's Min. Pet. Mitth., 1899, XVIII, 215.
[3] Coleman, Journal of Geology, 1899, VII, 437.
[4] Manual of the Geology of India. Econom. Geol. Part I. T. H. Holland. Corundum (1898), pp. 11, 37.
[5] Judd and Brown, Proc. Roy. Soc., No. 345, 1895. Cf. Amer. Jour. Sci. (4), 1896, I, 64.

and unsatisfactory character of our knowledge regarding the occurrence and origin both of jadeite and nephrite, and shows the necessity of much more detailed and careful observations before we attempt to generalize with confidence.

MINERALS SOMETIMES MISTAKEN FOR JADE

While it is the province of this volume to treat simply of the mineral *Jade* (nephrite and jadeite), it has been thought well to make mention of such minerals as are frequently mistaken for jade, and at the same time to furnish a few ready and simple means of detecting them without injury to the article examined.

The materials that have been mistaken for nephrite and jadeite are of three kinds:

First. Natural minerals that resemble nephrite or jadeite in color, toughness, or lustre.

Second. Minerals that have been stained or colored to imitate jades, sometimes with considerable success.

Third. Artificial imitations of jade, such as the glass mixtures.

The natural minerals that resemble jade, either nephrite or jadeite, and have been confused with them, may be grouped in three classes:

A. Those composed of silica alone, *i. e.*, forms of quartz, chalcedony, or jasper. In these the color may be due either to the presence of small amounts of oxide of iron or of chromium, or to the mechanical inclusion of considerable amounts of other green minerals, such as prochlorite, delessite, etc. These are all readily distinguishable from true jades.

B. Compounds of silica, *i. e.*, the silicates. This is a very numerous and complicated body of minerals, to which both jadeite and nephrite themselves belong; many of them are closely related to one another and to the true jades, and are similar, not only in aspect, but in structure and composition. Hence there are several members of the silicate group that are not easily distinguishable from jade, and their discrimination requires great care and experience. Others, while of similar aspect, can be readily determined.

C. Minerals which do not contain silica—phosphates and carbonates. These are few—turquoise, malachite, and mossotite,—all easy of recognition as not jades, though resembling some of them in color.

Among all the minerals here described as having been confounded with true jade, or liable to be confounded with it, only a few are incapable of ready distinction by the collector, by means of tests that are simple and easy. The hardness and specific gravity will decide in most cases, without recourse to any more elaborate methods.

As has been shown in the preceding pages, the true jades range in hardness from 6 to 7, and in density from 2.9 to 3.4. Jadeite is the harder and the heavier species, its hardness being 6.5 to 7, and its density from 3.20 to 3.41, as extremes; nephrite having a hardness of 6 to 6.5, and a density between 2.90 and 3.18. Any minerals, therefore, that fall outside of these limits, in either respect, are not jades.

All the forms of quartz have a hardness of about 7, but their specific gravity is from 2.59 to 2.66; some of the jaspers are at times a little higher, but much below nephrite, while the hardness compares only with the hardest jadeite. To the touch, also, there is a resistance of surface that is quite different from the smooth, unctuous feeling of the jades. Beryl, or emerald, with a specific gravity of 2.66 to 2.80, is far harder than any jadeite,—7.5 to 8,—easily scratching the hardest jade specimens. Amazon-stone, though in hardness about the same as nephrite, 6 to 6.5, has a density of but 2.54 to 2.57. Labradorite is a little heavier, 2.70 to 2.72, but hardness much less, 5 to 6. Any of the feldspar group that might possibly be encountered will fall between these limits; and their strongly marked cleavage tendency, often visible, and their total absence of fibrous or matted structure, are characteristic features of distinction.

Among minerals confounded with jade, perhaps the first place, both historically and in closeness of resemblance, belongs to that known as *saussurite.* It has been called *jade tenace* and *jade de Saussure*, and is a compact, tough, and heavy mineral, with splintery fracture, in hardness (6.5 to 7) and density (3 to 3.4) almost identical with jadeite; ranging from very translucent to nearly opaque, and in color from white to gray, grayish-green, and bluish-green. It was first noticed by H. B. de Saussure in 1780 ("Voy. Alpes," I, 112), and by him called *jade;* the name *saussurite* was given to it in 1806 by his son Theodore ("Jour.

Mines," XIX, 205). It is a Swiss mineral, occurring largely in boulders distributed in the glacial period over the Geneva region and the Rhone Valley. Guyot traced these to their source, 150 miles distant, in the chain of the Saasgrat. The late Professor T. S. Hunt, in 1858, recognized it as a soda-bearing variety of the mineral zoisite, and it is generally so regarded. But it is an alteration product, and, like all such materials, is not constant or homogeneous in either structure or composition. Zoisite is generally present in it, but sometimes replaced by epidote, while more or less feldspar and other accessory minerals are intermingled. It has been derived from feldspar by a chemical process known as "saussuritization." The texture is often so exceedingly fine-grained as almost to defy microscopic determination of its components.

Next in point of resemblance to jade is the mineral known as *fibrolite*, called in the United States *sillimanite*. It was a favorite material with prehistoric man in Central Europe, and has been mistaken for jadeite, which it closely approaches in aspect and structure. The density, 3.23 to 3.24, and the hardness, 6.5 to 7, as with saussurite, are about the same; when in a fibrous form it is densely compact and very tenacious—almost as much so as nephrite. It is a pure silicate of alumina (silica 36.8, alumina 63.2), often occurring in radiating or blade-like crystals, and passing into fibrous and massive. In this latter form it was largely wrought in prehistoric times into implements, multitudes of which have been found in France and Spain and described by Damour, Clarke, Quiroga, and others. To distinguish it from jade, otherwise than by analysis, it may be observed to have a visibly fibrous structure, less confused than nephrite, and less crystallization than jadeite, a lustre vitreous and not horn-like, as with nephrite, and a whiter aspect, inclining to pinkish or flesh-color.

In Alaska the natives of the coast have used quite extensively and for a variety of purposes—hammers, small celts, knives, scrapers, etc.—the mineral *pectolite*, in a massive form in which it much resembles jade. This is a silicate of lime and soda, closely related to jadeite (which contains no lime, however), and like it belonging to the pyroxene group. It is a mineral of the igneous rocks, and usually occurs in tufts and radiated masses of beautiful white, needle-like crystals, but is sometimes compact and massive. The specific gravity is from 2.60 to 2.87 (as in the Point Barrow specimens), close to that of nephrite; but the hardness is much less, being only 5, so that it is easily distinguished by being scratched with a knife or with a nephrite point. Before the blowpipe it fuses readily to a porcelain-like globule, and the flame is colored intensely yellow, indicating the presence of sodium. Though usually a very white mineral, that from Alaska has also many shades of green and yellow-green, and even when white always presents a distinct grayish-green tint. It is remarkably tough, and well suited for hammers.

Another mineral of the pyroxene group that is occasionally taken for jade is *wollastonite*—a simple silicate of lime with a very small percentage of magnesia and iron oxides, differing from pectolite just described in the absence of soda, and from jadeite in the absence of both alumina and soda. It is usually crystallized or has a marked crystalline structure, passing into cleavable massive and fibrous. In the last-named condition it might, like pectolite, easily be taken for jadeite; though it is not known to have been used for implements, as pectolite has. It has very nearly the toughness of nephrite, and about the same density (2.8 to 2.9); but its hardness is much lower (4.5 to 5), so that it may very easily be distinguished by this test alone.

There are two or three green to white minerals belonging to the group known as feldspar, that sometimes resemble forms of jade. Among these may be noted amazon-stone, euphotide, and saccharite. The feldspars are compounds of silica with alumina and one or more of the alkaline oxides—potash, soda, and lime. *Amazon-stone* is a bright verdigris-green or bluish-green variety of the species called microcline, a triclinic feldspar, containing 16 or 17 per centum of potash. It is not a common mineral, though found occasionally in various countries. The name *amazon-stone* is recent, and was given to it when brought from the region of the Amazon, in Brazil, in the form of numerous archæological ornaments. It is, however, easily distinguished from any of the jades by its much lower density, which varies from 2.54 to 2.57. Hence it is easily determined either by weighing or by the Sonstadt solution. The hardness is 6.5, that of nephrite; but it differs in its lustre, which is vitreous rather than unctuous, and in possessing a very marked and perfect cleavage, which can generally be detected by the eye without breaking the specimen, and an aspect, when closely examined, of fine parallel lines traversing the mineral.

Among the forms of *jade ascien*, which in former times served the natives of New Caledonia for the manufacture of their beautiful green adzes and beads, and was prized as an article of trade or of plunder among the inhabitants of neighboring islands, is apparently a green lamellar feldspar of the variety termed *euphotide*, somewhat altered, however, from its original condition. It is described as a beautiful green, translucent rock, of greasy lustre and splintery fracture, retaining in part the laminated aspect of a true euphotide which occurs not far away.

One more feldspar may be noted here as having been occasionally taken for nephrite when in rolled pebbles or fragments. This is *labradorite*, another triclinic soda-lime feldspar, of dark-gray or greenish color, with frequently a very beautiful play of iridescent hues, especially blue and green. This feature has given it the name of opalescent feldspar, and renders it a material of great beauty in the ornamental arts. The lustre is pearly, passing into vitreous or subresinous. It is rather a rare mineral, and may be distinguished from the jades by several features: *e. g.*, its lower hardness (5 to 6), its lower specific gravity (2.70 to 2.72), and its evident cleavage structure, as well as, generally, by its play of colors.

Two very important silicate groups, closely related in chemical and physical characters, and embracing numerous varieties under each, are pyroxene and hornblende (or amphibole). Jadeite, though distinct, is related to the former, and nephrite has been classed with the latter. There are some varieties of pyroxene, however, that closely approach the jades in aspect, and have been described as such, and some that seem almost intermediate varieties. Such are the "jades" of St. Marcel, Val d'Aosta, and Fay, and certain forms of diopside.

A grass-green pyroxene, granular to foliated, called *omphacite*, intermingled with garnet, forms a peculiar and beautiful rock known as *eclogite*, often interlaminated with a bright-green amphibole called *smaragdite*. This omphacite has a specific gravity of 3.2 to 3.3,—about that of jadeite,—a hardness rather lower, 5.5 to 6, and the cleavage of pyroxene. To it have been referred two noted instances of supposed jades—those of Val d'Aosta and St. Marcel.

A pebble found by Dr. Pitorre in the Val d'Aosta, on the road to Little St. Bernard, had a hardness, density, and fusibility similar to those of jadeite, a beautiful grass-green color, and a fibrocrystalline structure. It much resembled some Chinese specimens, and was believed at first to be identical with them. A similar stone was found at St. Marcel, in Piedmont, by Herr Bertrand de Lon, forming a small vein in white quartzite. Fischer regarded both of these as omphacite, to which they approach somewhat on analysis. Meyer ("Jadeit und Nephrit Objecte," II, 13) considers them to be intermediate substances between jadeite and nephrite.

The Fay specimen was a green crystalline mineral from the village of Fay, in the department of Loire Inférieure, France, not far from Nantes. It contained red garnets and formed a vein in gneiss; the hardness, density, and fusibility were nearly the same as in jadeite. From its mode of occurrence, Fischer referred this substance also to omphacite, but an analysis by Damour showed it to be quite different, and nearer to some of the true jadeites, especially of the chloromelanite type.

Diopside is a true pyroxene, in color varying from white through yellowish and grayish to pale green, and sometimes dark green. It is usually found in prismatic crystals, which, when transparent and of fine color, have sometimes been cut as green gems; but it also occurs in granular, columnar, and lamellar masses, and has then in some instances been taken for jade. The density is 3.20 to 3.38, and the hardness 6 to 6.5. The principal characters by which it may be distinguished from jadeite are its facile cleavage and its usually greater translucency. On analysis it yields silica 55.6 per centum, alumina 25.9, and magnesia 18.5; while jadeite has less alumina, almost no magnesia, and considerable soda.

Nephrite, as above stated, is a variety classed with the amphibole or hornblende group; another variety is known as *actinolite*, very closely akin to nephrite, in some of its forms having been taken for it. Actinolite is usually in slender crystals, radiating or matted together, and passing into fibrous and asbestos-like forms; the color is light to dark green. Some specimens of a massive pale-green mineral, from the Rylshytte mine, near Garpenberg, Dalecarlia, Sweden, were sent for analysis to Meyer, Frenzel, and Cohen, under the supposition that they might be nephrite. Chemical and microscopical examination showed them to be dense actinolite, rather too soft and coarsely granular for nephrite, and without its typical fibrous tufted structure.

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No. 685

ARTIST'S BRUSH-HOLDER

(*Pi T'ung*)

Ch'ien-lung (1736–95)

Nephrite

At the head of all green minerals, for beauty and value, stands the *emerald*, a variety of beryl. It has been prized as a gem from the remotest antiquity, and maintains its rank unrivalled and unimpaired. So far as any resemblance to the jades is concerned, it is only the rougher and more opaque forms of emerald that could be so confused; but with those it is quite possible, and hence its mention here.

Beryl is a silicate of alumina and the rare earth glucina, containing silica 67 per centum, alumina 19, and glucina 14. It varies from very pale green to light blue and to golden yellow, with all intervening tints, and if a small amount of oxide of chromium is present the green becomes deep and brilliant, producing the emerald. The hardness is 7 to 8, and the specific gravity 2.7; the lustre is vitreous, and sometimes resinous. The mineral crystallizes in six-sided prisms, only rarely becoming columnar or massive. It is generally translucent,—varying from transparent to opaque,—and brittle with conchoidal or irregular fracture.

In massive pieces, when opaque or subtranslucent, either beryl or emerald may resemble nephrite; and there has very likely been confusion between them in the case of some archæological objects. But beryl, or emerald, can very easily be distinguished from any jade, (1) by its greater hardness, readily scratching both nephrite and jadeite; (2) by its less density, 2.6 to 2.8; and (3) by the absence of cleavage and also of anything approaching the fibrous texture of nephrite.

One of the minerals that most frequently resemble certain of the jades is the silicate of magnesia known as *serpentine*, and especially a white or pale-greenish variety called *bowenite*. Serpentine is abundant in many countries, and has an endless variety of shades of green, from pale to yellow-green, and waxy brown, olive, bluish-green, to almost jet-black, often intermingled in spots and clouds of different tints. It was rarely used for celts, as it is not very hard and is somewhat fragile. But many art objects have been made of serpentine, which to the unpractised eye easily pass for nephrite. Its inferior hardness, however, never more than 6, and usually between 4 and 5; its low specific gravity, never above 2.65; its greasy rather than unctuous lustre and feel; and the readiness with which it loses its lustre before the blowpipe and generally turns whitish-gray, readily distinguish this mineral in its many varieties from both nephrite and jadeite.

Most of the serpentines are opaque, but the variety known as precious or noble serpentine is translucent and makes a beautiful ornamental stone, but is very soft,—2.5 to 3,—scarcely as hard as ordinary marble. *Antigorite* is a lamellar variety from the Antigorio Valley, in Piedmont, sometimes of a rich leek- or emerald-green by transmitted light, but also not harder than 2.5. *Williamsite* is a beautiful variety from the chrome-mine at Texas, Lancaster County, Pennsylvania. It is harder (4.5) and of exceedingly rich colors—emerald-green and blue-green, sometimes mingled with white, strongly resembling some of the handsomest of Chinese jades. It probably owes its peculiar beauty of color to oxide of nickel, and sometimes contains small disseminated crystals of chromic iron.

The variety *bowenite*, however, is the form of serpentine that has really been confounded with nephrite. It is a compact variety, white and grayish-white to pale green. It was found at Smithfield, Rhode Island, by George T. Bowen, and described by him as nephrite, in 1822 ("Amer. Jour. Sci.," V, 346). Dana, however ("Syst. Min.," 1850, p. 265), recognized its character and gave it the name of *bowenite*. It has the unusual hardness, for a serpentine, of 5.5 to 6, a density of 2.6 to 2.8, and a greater toughness than probably any variety of this mineral elsewhere known. It is massive, very fine granular in texture, and closely resembles jadeite.

The *tangiwai* variety of New Zealand greenstone, usually classed as jade, is apparently the same as bowenite—a hard, compact serpentine. It has the same hardness, and very nearly the same density, but is bright green and translucent. This mineral has been frequently confounded with jade.

A jade-like stone called *sang-i-yashm* by the Persians is only another form of this same bowenite. It varies from dark grayish-green to pale sea-green, mottled with white, and is worked into small articles of ornament at Bhera in the Punjab. It has, however, the inferior hardness (5) and density (2.59) which belong to the serpentines and readily distinguish it from any of the true jades.

Among the numerous varieties of non-crystalline or cryptocrystalline quartz, which vary from translucent to opaque and present many tints and shades of color, there are several green varieties that have been, and may be, readily confounded with jade. Four of these may be briefly referred to here, and their distinctive characters indicated. These are prase, plasma, chrysoprase, and green jasper.

Prase is a dull-green, semi-crystalline quartz, sometimes approaching leek-green. It has never been much valued for an ornamental stone, as its colors are not rich or clear, but its aspect is not at all unlike certain of the jades.

Plasma is a closely related variety, often spoken of as leek-green, sometimes even emerald-green, translucent or subtranslucent. From its frequent bright-green tint, almost the peculiar yellowish- or golden-green of some of the finest nephrites, especially as seen by transmitted light, plasma is easily mistaken for them, but is readily distinguishable.

Chrysoprase is another variety of chalcedony (or carnelian), a translucent cryptocrystalline quartz, colored a rich, delicate apple-green by a small quantity of oxide of nickel, from one per centum to four tenths of one per centum of which is present. It is a beautiful stone, but of rare occurrence.

Green jasper is another mineral of the same general group, but an opaque and amorphous variety of quartz, lacking the translucency of the previous kinds. The coloring matter is generally oxide of iron, the protoxide giving the green tints and the sesquioxide the yellows and reds that appear in many jaspers. Sometimes the two are mingled in bands or spots, as in the dark-green variety flecked with bright-red specks or drops, known as bloodstone or heliotrope. Green jasper has often been confounded with jade; so that many of the earlier references to jasper may have been really to jade, and *vice versa.*

Besides these varieties, there are several that resemble them, but owe their green tints not to the presence of coloring oxides, but to the mechanical inclusion of other minerals. Much green jasper, particularly the bloodstone variety above mentioned (properly called *heliotrope*), owes its color to the presence of a large amount of dark-green delessite (a chlorite-like mineral—a hydrous silicate of alumina, magnesia, and iron) included in the chalcedonic base. In the same way, some prase is a chalcedony colored by minute inclusions of prochlorite (a silicate similar to delessite). Such is probably the supposed jade from Corsica, which was mentioned as a locality for jade by Lenz in 1800, and Von Leonhard in 1808. On investigation of a specimen in the University Collection at Strassburg, labelled "Nephrit aus Corsica," Fischer found a prase-like mineral, which, however, gave an uncertain result upon analysis, not corresponding to nephrite and very far from prase. It showed considerable alumina, magnesia, and iron oxide as present, and is probably a quartz with inclusions of some chloritic mineral. Occasionally quartz is so filled with prochlorite as to resemble some of the dark varieties of chloromelanite; and if either quartz or chalcedony contains such mineral in large proportion, as the specific gravity of prochlorite varies from 2.80 to 2.96, the specific gravity of the mixture might easily be raised to very nearly that of nephrite.

Other varieties of this kind are the so-called Chinese *moss-agate*, a very beautiful stone, really, in most cases, from India, near Ahmedabad. Here a translucent white or bluish chalcedony is filled with green, moss-like or seaweed-like markings, which were formerly supposed to be of vegetable origin, but are merely fine crystallizations of metallic oxides, chiefly iron, forming patterns like those of frost-work on a window-pane in winter, or a green earthy delessite or prochlorite sometimes vermiform. At times these become so dense as to fill up the stone, which then presents a homogeneous dark-green color, like that of a rich jade.

Many specimens of so-called "imperial jade" (the *fei-ts'ui* of the Chinese) have proved on examination to be the beautiful green *aventurine.*

All these more or less jade-like varieties of quartz may be distinguished by characters easily determined. As compared with either nephrite or jadeite, they have a somewhat greater hardness (7) and a less density (2.60 to 2.65), and so may be separated from them either by direct weighing or by the Sonstadt solution. The quartz minerals all have a greater resistance to the touch, and there is nothing like the horn-like structure and fracture of nephrite or the crystalline texture of jadeite. The structure of the jaspers is wholly amorphous, and that of the other varieties described is cryptocrystalline. In microscopic examination they are found to possess the optical properties of quartz, which belongs to the hexagonal system.

An exception may be noted in regard to the density, in the cases above referred to, where a large amount of included foreign matter of greater density may raise the specific gravity above that of quartz to nearly that of nephrite; but the other characters remain as means of discrimination for all forms of quartz.

The remaining minerals, except the really difficult ones to be specially noted beyond, are very much softer than any real jades, and can be at once separated. *Agalmatolite* in all its forms, natural or carved and stained

for imitation, oncosin, chonicrite, etc., fall under this general statement; their hardness rarely exceeding 3,—often less,—so as to yield to the first touch of a knife. The same may be said of the serpentines, though some of them occasionally have a higher hardness (*williamsite*, 4.5), and all are also less dense, averaging from 2.5 to 2.6 in specific gravity. Bowenite alone among serpentines is both hard and heavy enough to have been seriously confounded with nephrite.

The really difficult minerals will now be briefly dealt with; of these there are only a few, as follows:

A delicate, pale-green, translucent mineral named *prehnite*, after an early discoverer, Colonel Prehn, has in some instances been mistaken for jade. It is a silicate of alumina and lime, with a hardness of 6 to 6.5 and a density of 2.80 to 2.95, closely approaching nephrite in both these features. It is light green, or oily green of various shades, but differs from nephrite in its vitreous lustre and very markedly in its lack of toughness, being so brittle as to break quite readily. It is one of the minerals found in the cavities of trap and similar rocks, and never occurs in large masses, though small pieces of it are sometimes cut and polished for ornamental work. But it is not known to have been used by prehistoric man at all. It is quite possible that some small Chinese objects may prove to be prehnite.

Epidote is another complicated silicate, somewhat similar in composition to the last, but with more iron and alumina and little or no magnesia. It has various shades of yellowish- and olive-green to almost black, and is frequent in prismatic crystals, monoclinic, but very much modified, in metamorphic and sometimes in igneous rocks; also granular and forming at times rock-masses. Its hardness (6 to 7) and density (3.25 to 3.50) are close to those of jadeite, but it has a strong cleavage and a vitreous lustre. Epidote is sometimes one of the minute components of saussurite, elsewhere described; but it is not a mineral likely to be confounded with jade, save in the following relation: It often occurs intermingled with quartz or with orthoclase feldspar, or with both, at the juncture of a vein in a coarse granular or pegmatite rock. The fine intermixture of the green epidote with the white or flesh-color of the quartz and feldspar produces a mottled yellowish-green that resembles some varieties of nephrite. As the hardness and density are near those of jadeite, it might be taken for that mineral when the epidote was predominant, and for nephrite if the density of the mixture was brought below 3 by a large proportion of the other minerals. Before the blowpipe, however, epidote fuses at 3.5 to a dark or black mass that is frequently magnetic, owing to the large content of iron in the mineral. The separate crystals are quite brittle, but as a rock-mass, or in a rock-mixture, it is tough.

Vesuvianite, or idocrase, is a mineral that in massive form has been taken for jade in a well-known instance. It is a complex silicate of alumina, lime, magnesia, and iron, and is named from its frequent occurrence in the lavas of Vesuvius; but it also occurs in many metamorphic rocks, serpentines, limestone, etc., usually in square prismatic crystals, but sometimes massive. Its color is brownish-green, olive, yellow-green to brown, or even yellow; hardness, 6.5; specific gravity, 3.35 to 3.45; lustre vitreous, inclining to resinous; fracture subconchoidal to uneven; texture brittle. This last feature and its marked translucency and vitreous lustre are the best external distinctions of idocrase from jadeite, for which it was taken by Von Fellenberg ("Jahrbuch für Mineralogie," 1889, I, 103); but it was identified by Damour and others.

In 1887 Berwerth described a jadeite from Borgo Novo, Graubundten ("Ann. Hof. Nat. Mus.," Wien, 1887, II, hft. 3), and Virchow referred to it from this locality in the "Zeitschrift für Ethnologie" (1887, p. 561). It seems, however, that this was a mistake, owing to specimens having been sent for examination from a Professor Stampe of Borgo Novo, and that the real locality, as announced by Von Fellenberg, was in rolled masses in the bed of the Orlegna, near the village of Casaccia, in the Upper Engadine. He and Professor Stampe discovered it in place on the south side of the Piz Longhin, in the Bergellthal, near the foot of a precipitous mountain wall. They found it as a white vein forming lens-shaped masses in a hard yellowish-gray rock. Subsequent examination of this Piz Longhin material by Meyer and Frenzel ("Neues Jahrbuch für Mineralogie," 1889) proved that it was not jadeite, but a compact form of vesuvianite. An identical mineral is californite, recently discovered in large masses in Siskiyou County, California (Kunz, "Amer. Jour. Sci.," Nov., 1903, XVI).

Agalmatolite, pagodite, or Chinese figure-stone, is one of the minerals most frequently sold to the inexperienced or unwary traveller in China under the name of jade. It is at once distinguishable, however, by its softness. Its structure is very compact, fine, and homogeneous, and takes the most delicate tool-marks,

making it an ideal material for carving. Its natural color is whitish, grayish, or yellowish; but it readily absorbs coloring matters, and is frequently stained green or greenish to imitate nephrite, sometimes clouded or spotted with brown. Agalmatolite is an altered mineral derived from two or three species of aluminous and magnesian silicates; much of it is essentially pinite, though containing a little more silica; some of it is pyrophyllite, and some is practically steatite (compact talc). In all its forms, however, the hardness is only from 2 to 3; so that a mere touch with the knife, or even rubbing with the hand, is enough to distinguish it from jade. To the touch it is soft and unctuous, and the specific gravity varies between 2.7 and 2.9.

A beautiful variety of what seems to be the same stone is found near Washington, Georgia; this is often translucent, and of a very attractive bluish-green to emerald-green color. It was carved by the Indians into banner-stones and similar ornaments, which are sometimes found in ancient graves in Georgia and the Carolinas, and have repeatedly been taken for nephrite.

Turquoise, the Turkey-stone of the sixteenth and eighteenth centuries, was so called from having reached Europe from the East through Turkey. It is obtained chiefly from mines in Persia, at Nishapur in Khorassan, though found at a few other points, and it has been used as a gem from very early times. The proper color of turquoise is sky-blue, inclining slightly to green; but much of it is of greenish-blue and green tints, and the inferior qualities are pale and muddy yellowish-greens. The blue tint so much prized is often readily altered to green, both naturally by exposure to the weather, or even to the air, and artificially by heat; or, when worn, by contact with fatty acids, perspiration, soaps, or perfumes; so that turquoises must be kept for some time, before mounting for jewelry, to see if this color is permanent, and must be worn with care, especially as to contact with soaps and perfumes, the oils from which are very apt to alter the color.

The green varieties of turquoise much resemble jade, but may be distinguished quite readily in several ways: (1) by the lack of toughness; (2) by inferior hardness, being only 6; (3) by the lower specific gravity, 2.6 to 2.8, easily determined either by weighing or by the Sonstadt solution; (4) by the texture, which is compact and smooth, with no trace of anything either fibrous or crystalline—a scraped surface having the perfect smoothness of soap or ivory when cut with a knife; (5) by the complete absence of cleavage and by almost uniform opacity. Turquoise is a hydrous phosphate of alumina, the color being due to a small amount of copper compound, probably a phosphate.

The ancient Mexicans had a green stone which they prized highly, and carved into a variety of ornaments and talismans. This they called *chalchihuitl*, and it has figured largely in American archæology. Professor W. P. Blake, writing on the discovery of the ancient turquoise-mines in New Mexico ("Amer. Jour. Sci.," 1858, XXV, 227; and 1883, XXV, 197), argued strongly that this was the celebrated and mysterious chalchihuitl. Others regard it as rough emerald, and others perhaps as jade. The name was no doubt a general term covering several kinds of handsome green minerals rather than any one in particular.

The celebrated and beautiful stone called *malachite* is a hydrous carbonate of copper, rarely crystallized, but often fibrous and massive, with a mammillary or "botryoidal" surface. The color is brilliant emerald-green, lighter and darker, frequently finely banded and clouded in different shades, and usually quite opaque. It is found all over the world, but rarely in large masses. All races and periods have known and used it; and some malachite articles have been mistaken for jade. There need never be any question, however, as its hardness is much less (3.5 to 4), it is easily scratched with a penknife, and its density is much greater (3.9 to 4) than those of either nephrite or jadeite. A drop of nitric or hydrochloric acid at once causes effervescence, liberating the carbonic-acid gas. Moreover, its brilliant color, its opacity, and the very general appearance of fine agate-like bands and lines, concentric or wavy, parallel all through it, in lighter and darker green, are unlike any aspects of jade.

One more mineral may be mentioned as being possibly confounded with jade, but very easily recognized by tests similar to the last. This is *mossotite*, a rare variety of aragonite, a carbonate of lime, colored a delicate light greenish-blue by a trace of copper. The color is very characteristic of jadeite; but the hardness is only 3.5 to 4, as in malachite, and the acid test acts in precisely the same way, causing effervescence and showing it to be a carbonate. A lens reveals at once the fibrocolumnar structure of aragonite.

Chonicrite is a massive, crystalline-granular to compact mineral forming seams in serpentine rock on the island of Elba. It has a specific gravity of 2.91, a hardness of 2.5 to 3, a white color, and a faintly glim-

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No. 440

BUDDHIST MONK

(*T'ang Sêng*)

K'ang-hsi (1662–1722)

Nephrite


A. Leveille sc

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mering or silky lustre. To this has been referred, as closely allied, a supposed nephrite found near Easton, Pennsylvania, in 1824. Fischer, in 1865, showed it to be near chonicrite, and gave it the name of pseudo-nephrite ("Jadeit und Nephrit," p. 244).

Possibly in no country more than in China have so many substances been mistaken for jade, due probably to the fact that exact mineralogical knowledge does not exist there. In no country in the world is jade more sought for and used; and, at the same time, nowhere have more clever deceptions been practised in the polishing of the surface than in China.

One who is not well versed in the study of jade may be surprised at the absence from the Collection of what has been so much spoken of from time to time by collectors as *pink jade*. In reality, the only specimens of jade that have any approach to pink are the Burmese pieces, in which the color is not really pink, but a pinkish-lavender. That this form of jade is not represented may be readily explained by the fact that true pink jade is probably unknown; although many specimens have been sold as such from time to time at fabulous prices by dealers on both sides of the Atlantic. A careful examination of these so-called pink jades was made, with the following results:

First. The specific gravity of all the pieces examined varied from 2.60 to 2.63. *Second.* The hardness of all the pieces was 7. *Third.* In several small transparent spots in the object it was possible to place the translucent parts under the stauroscope, and to prove that the material crystallized in the hexagonal system. It required but a single specimen to prove that the material itself was pure silica, and when the hand was rubbed over the object the surface offered that resistance peculiar to quartz, and not the soft, unctuous feel of nephrite, or the peculiar, almost slippery feel of jadeite. The pink color of all these objects was very striking—not a natural color, in fact, but a strong aniline in character. With a pocket lens it could be readily seen that the objects were fissured and flawed partly through, naturally and closely, but that probably they had also been crackled, and that in these minute cracks alone could the coloring matter be found. A bit of cotton, saturated with alcohol and carefully rubbed over a part of the object, in all instances brought forth a bit of aniline stain, leaving no question as to the fact that the objects had been made out of a crackled, almost milky quartz by being heated and plunged into cold water or a cold aniline solution; or that the material had been crackled and the objects then boiled for some time in an aniline solution. The boiling would expel all the air from the cracks and close them, and upon cooling in the solution the cracks would again open and absorb the coloring material. They were then washed, and to the practised eye appeared more brilliant, more beautiful, and more charming than any piece of natural jade ever produced. This imitation is somewhat like the blue, green, and red gems that have been made for the past century and generally sold under the name of Mont Blanc rubies, sapphires, and emeralds, and by the French called in the latter part of the eighteenth century *rubasse*. In the latter case, however, pure rock-crystal was used, and it was only flawed enough to absorb the color, giving the appearance, when stained, of a transparent blue, green, or red gem.

One of the simplest, most common, and most ingenious of all artificial jades is that made of a heavy "paste" glass—a lead glass containing a quantity of oxide of lead in place of the soda in ordinary glass. This material is colored, with wonderful skill and fidelity to nature, to imitate all varieties of jade. A frequent kind is made pure white and nearly opaque, with rich splashes of green, to simulate the *fei-ts'ui*, the so-called "imperial jade" of China. This form may be found in bracelets, earrings, and other trinkets, wherever a Chinese shop exists. Again, it is made altogether green—the particular bluish-green of the Burmese jadeite—and sold in the same forms as the last. Another kind is entirely white or faintly tinged with lavender to imitate the white and lavender jades. Some glass has been made almost of a black-green. One well-known imitation is given the rather pleasing French name *pâte de riz*, as though a rice-paste ingeniously united and hardened; whereas it is merely a white glass with a faint tint of bluish-green or bluish-gray.

But the coloring is by no means all. The expert Chinese glass-makers well understand the art of deadening the lustre of the surface, first producing a high polish, and then with a fine, hard powder reducing it slightly so as to impart to the glass almost precisely the lustre of jade. These imitations, moreover, are not confined to small objects, but many very fine and large pieces have been made, which represent, of course, only a trifle of the experience and a fraction of the time of the carver, as compared with such objects in real jade.

PART IV

METHODS OF WORKING JADE

No. 289

AXE

Nephrite

New Caledonia

No. 296

WAR CLUB

(*Meré*)

Nephrite

New Zealand

No. 286

ADZE

Nephrite

New Zealand

201

METHODS OF WORKING JADE

THE art of fashioning and carving jade might theoretically be investigated in two different ways. The first would be to start with the earliest implements and weapons, laboriously worked by prehistoric peoples of neolithic ages; to compare these with aboriginal tools produced in modern times by natives of New Zealand and the Pacific islands and by savages of Alaska and British Columbia, who represent the same grade of culture as the prehistoric tribes which worked jade; and to notice the steady advance consequent on the gradual adoption of new appliances and improved methods of work. The second would be to begin with the finished methods of manufacture of the present day in China and India; to compare these with the actual technique of workers in hard stone in Western countries, derived, as it is, from that of the unrivalled cameo and intaglio sculptors of classical times; and to proceed afterward to the ruder handiwork of earlier ages and less advanced people. The first way would be more satisfactory if only we had a more exact knowledge of the early methods of working jade, but the second is more convenient here, and it has the advantage of allowing us to proceed from the known to the unknown.

It seems fitting to begin with China, which is, par excellence, the country of jade, and is, consequently, the one most abundantly represented in the Collection. The services of a native artist have been secured to give us a series of water-color pictures, painted on the spot, of the various processes now followed in the jade workshops of Peking, and he has, with Chinese patience, industriously reproduced a sufficient number, in facsimile, for our purposes. Peking has become under the present dynasty, which began to reign in 1644, the centre of the manufacture of jade in China, since the establishment of an imperial workshop, called *Yü Tso*, within the walls of the imperial palace, which has turned out a succession of the finest pieces of artistic work, many examples of which are now in the Collection. In former times Soochow, in the province of Kiangsu, was the principal centre. There are, besides, jade-workers in Momien and Yungch'ang for the local productions of the province of Yunnan and for importations from Burma; and there is a whole

street of jade-factories in Canton, into which city jadeite is imported in large quantities from Burma to be worked into art objects, generally small in size, and a profusion of personal ornaments for rich Chinese of both sexes, which are exported to all parts of the empire.

The artist, Li Shih-ch'üan, has faithfully represented the successive steps of work on a piece of jade, down to the minutest detail, in the thirteen illustrations which are to be found in the Chinese article.

The following are the processes of work and the various kinds of apparatus represented in these thirteen illustrations, of which two are painted on each page, the first two being, moreover, combined in the same picture for economy of space:

1 Pounding the Sand (Emery)
2 Grinding the Sand (Almandin)
3 Sawing open the Crude Jade
4 The Slicing Saw
5 The Shaping Wheels (Lap-Wheels)
6 The Grinding Wheels
7 Hollowing the Interior by the Tubular Drill
8 Carving Ornamental Designs
9 The Diamond Borer or Drill
10 Openwork Carving
11 Piercing Holes by the Diamond Drill
12 The Wooden Polishing Wheel
13 The Leather Polishing Wheel

As he justly says, many different kinds of tools are employed in the work, but all owe their efficiency to the pounded sands used with them, without which they would be useless. The different kinds of crystalline sand used in China vary in composition, color, and biting power: the "black sand" with which the first hand-saw is smeared is a kind of emery; the "jewel dust" which gives the final polish to the jade is usually garnet sand, or almandin.[1] The large blocks of crude jade, weighing over a hundredweight, are first sawn apart by two men working with a four-handed toothless saw, the blade being a plain strip of thin iron which is kept at full tension in the way shown in the picture.

In Burma, as described by Dr. Nisbet, Conservator of Forests in 1901, the first slicing of the blocks of jadeite is done in the same way as in our third illustration, only in a more primitive fashion, by means of wire stretched upon a bow. He says: "The blocks of jade are mostly brought down from the mines in Upper Burma to Mandalay to be sawn up. The way in which the large blocks are manipulated may be seen any time one drives along China Street, the long road leading from the southwest corner of the walls of Mandalay city southwards to the Arakan pagoda. They are sawn through by hand with piano-wire, strung tightly across a bent piece of wood, under the action of water constantly dripping from a vessel hung above the block. To assist the process fine sand is strewn on the stone where the wire saw works. The exterior of the blocks is oxidized to a grayish-brown color, but the ooze trickling down on both sides of the stone as the saw passes backwards and forwards is of the green color that one would expect from jade. The exterior of the block seems to give absolutely no indication of the quality of the jade lying at its core, and in so far the traffic in rough blocks is about as complete a mercantile example of buying a pig in a poke as can be imagined."

Our artist aptly compares the process under consideration to that of peeling an orange to get at the fruit, and says that it is completed by hanging the block that has been sawn out upon the end of a rod suspended from the ceiling with a counterpoise at the other end to balance it, and slicing off all superfluities on the lathe with an iron circular saw of the kind figured in the illustration (fourth). The horizontal lathe commonly used in Chinese workshops is faithfully represented in several of the pictures. It is seen there to consist of a wooden framework with a vertical block standing upon it, which is perforated to hold the pin attached to one end of the revolving horizontal spindle on the other end of which the cutting or polishing

[1] The Japanese use almandin to give the last polish to their balls of rock-crystal and other carvings in hard stone. Ruby dust also seems to be employed in China, being brought from the province of Yunnan and from Tibet.

instrument is mounted. The spindle is kept in rapid reciprocating movement by a hempen cord passed once round it, the ends of which are attached below to two rocking pedals, worked by the feet of the artisan, whose hands are thus left free to manage the work. The piece of jade is roughly sliced into the outline required by one of the graduated circular saws shown in No. 4, the edges of the discs of which are thinned to a knife-like sharpness; then the prominent angles left by the saw are ground down and the piece is further shaped by the more solid iron rings seen in No. 5; and lastly, the striated marks of the grinding are removed by one of the iron polishing wheels shown in No. 6. The object is now ready to be carved with artistic designs in relief, or to be pierced through and through with the diamond drill and afterward carved in open fretwork with the wire saw, in the way that will be described presently.

But before passing on to these branches of work, the artist gives us, in No. 7, a picture of the working of the tubular drill, which is a very ancient instrument found in all parts of the world.

In China the tubular drill consists of a short iron tube, grooved in two or three places to hold emery, and mounted upon a light iron spindle which is kept in motion by a leather strap worked by treadles. As it works it leaves behind a core, which has to be dug out afterward by little gouges of varied shapes, made to fit into the hollow end of the same iron spindle. A number of other small instruments are adapted for working on the same lathe to scoop out the interior of a vase, when it is necessary to increase its capacity after it has been bored by the iron drill and the core dug out. One of these iron drills, obtained from Canton, may be seen in London, in the Museum of the Royal School of Mines.

The account of the tubular iron drill as a separate branch of work has diverted us from the main road for a while. In the previous illustration we had the piece fashioned into the shape required by sawing, grinding, and polishing, and made ready for carving and other decorative operations of a more artistic kind. Occasionally a rolled pebble may be taken fresh from a river-bed, without any of these preliminary preparations, having been moulded by the hand of nature into quaint form and attractive coloring, to serve as a bottle for snuff, or a "hill of longevity," which is carved all over with Taoist figures wending their way through tree-clad mountain paths toward temples of paradise, or some such scene. The artist takes advantage of the natural inequalities and varied tints of the surface of the pebble to eke out and emphasize the details of his studied design.

The process of carving a piece of jade with ornamental designs in relief is shown in No. 8. The lathe, similar to the last, has an iron spindle, into the hollow end of which are lightly hammered the little iron discs, or lap-wheels, with which the work is executed. The Chinese lapidary calls the smaller discs "nails" because they are exactly like small flat-headed nails. The process need not be further described, as it is precisely like that employed by cutters of jewels and hard stones throughout the world. Mr. C. W. King, in his "Antique Gems and Rings," defines the *Wheel* as "a minute disc of metal fixed at the end of a spindle which is set in rapid motion by a kind of lathe; the fine edge, constantly charged with emery or diamond powder, cuts in, dexterously incising by repeating and prolonging the strokes." In China all sculptured work in relief upon jade, whether the piece be large or small, is executed by these little discs; and they are also used there for cutting rock-crystal, amethyst, carnelian, agate, and the other hard stones which are carved by Chinese lapidaries into vases of varied form and into figure subjects.

The representative series of Chinese artistic work in other hard stones than jade, with a few examples of Japanese carving in rock-crystal, which form an important part of the Collection, may be just referred to here as numbering nearly two hundred pieces, although it would be outside the plan of the work to describe the pieces in detail. The Chinese materials include, in addition to several varieties of those mentioned above, beryl, chalcedony, malachite, lapis lazuli, and many others of the semi-precious stones which are so highly appreciated in the far East.

The process of carving jade in openwork designs is divided into two stages, which are illustrated in the next two pictures, Nos. 9 and 10. The object has first to be pierced through and through with the diamond drill, and then into the holes thus made the wire saw is inserted, and carried, step by step, by the power of the biting sand which is used with it, through all the intricacies of the most complicated fretwork pattern. The diamond drill is seen at work in No. 9, kept in revolution by the usual string-bow wielded by the right hand of the operator, while he holds the jade in his left; the cup-shaped head-piece of the drill is fixed above

to a horizontal bar, on which is hung a heavy stone weight as a counterpoise, so as to give the necessary pressure in the ingenious way shown in the picture. The second stage of the *à jour* decoration is shown in No. 10, and it is so well described by the artist that there is nothing more to be said. It speaks volumes for the patience of the Chinese lapidary that he will laboriously execute in such a hard material the complicated fretwork designs of an ivory-carver or wood-cutter, and work out with such a simple tool the elaborate pierced designs which distinguish some of the artistic pieces in the Collection.

The next illustration, No. 11, exhibits another phase of the diamond drill, as it is being used by the Chinese lapidary for boring small articles of jade, such as rings, snuff-bottles, mouthpieces of tobacco-pipes, and the like. The small object under treatment is provided with a little boat-like support of wood shaped for the purpose, so that it may be floated upon water in a miniature bamboo tub, while it is being bored by the drill. The cup-shaped head-piece of the drill now rests in the left palm of the craftsman, who thus keeps it pressed down while he works the string-bow which he holds in his right hand. The diamond drill, as figured here, may be seen at work every day among the Chinese, who use it when riveting porcelain and glass, as well as for driving holes through pearls and precious stones. The use of the diamond for carving jade is referred to as early as the ninth century in the "Annals of the T'ang Dynasty," in the account of Kambodia, where the diamond is described, under its usual name of *chin-kang*, as resembling the amethyst, and as being generally mounted there as a drill upon horn. The Kambodians must have received it with the rest of their culture from India, and the Chinese doubtless obtained it, directly or indirectly, from the same source.

The ancient Hindus probably got it originally from Chaldea. The diamond point is generally recognized, according to Mr. King, as the regular engraving-tool of the East, and is actually designated in a record of the highest antiquity, and by a resident among the Chaldeans, its first inventors — the prophet Jeremiah (xvii. 1): "Peccatum Juda scriptum est stylo ferreo in ungue adamantino, exaratum super latitudinem cordis eorum, et in cornibus ararum eorum," as the Vulgate more correctly than our Version renders the passage. It was well known to Arabian seal-cutters of the thirteenth century, and it is still used by the Persians to inscribe texts from the Koran upon slips of nephrite which are worn by them as talismans.

The ancient Egyptians in far earlier times are said to have carved the hardest granite and diorite with bronze tools mounted with diamond points. Some think that the diamond drill was known to the Babylonians at an early period, and that it was very likely obtained by them from Egypt; but these points, which are still unsettled, are fully discussed by Mr. J. D. McGuire in the "Journal of the Smithsonian Institution," 1896, in a paper on "Primitive Methods of Drilling."

The fabric of the piece of jade is now complete as far as the carving in relief and the openwork incision of the body are concerned, but the surface still requires a patient process of polishing to bring out more fully the intrinsic merit of the material. The harder the jade, the more it will repay the most patient handiwork of the craftsman, who must be careful to rub down all scratches and angles left by wheel or saw, as he follows with his wheels and polishing points every detail of a complicated carving, and goes over the ground again and again till quite satisfied with the result. By these means only can be produced in hard stone the fluent lines and delusive softness of the perfect piece which delight the connoisseur and remind him of the flowing outlines of a moulding in wax. So the Chinese liken a finished work in white jade to liquescent mutton-fat, or, again, to congealed lard, shaped, as it were, by the fire. The artistic aim and methods of the classical glyptic artist were curiously similar. A study of the finest intaglii, as Mr. King says, shows that the old sculptor, having first sunk his work to the depth required with the drill, and then completed all the details with the diamond point, finally removed all traces of the instruments employed by the high polish he imparted to his work as the concluding operation; thereby giving it the effect so characteristic of the truly antique intaglio, that almost melting outline which leaves nothing angular or sharply defined, but rather makes the whole figure appear modelled by the most delicate touch in some soft and plastic substance.

The polishing processes by which all traces of the cutting and grinding instruments are removed in China are shown in the next two illustrations, Nos. 12 and 13. The tools used are of soft material, being made of fine-grained wood, dried gourd-skin, or leather; the actual work being done by the finely pulverized "jewel

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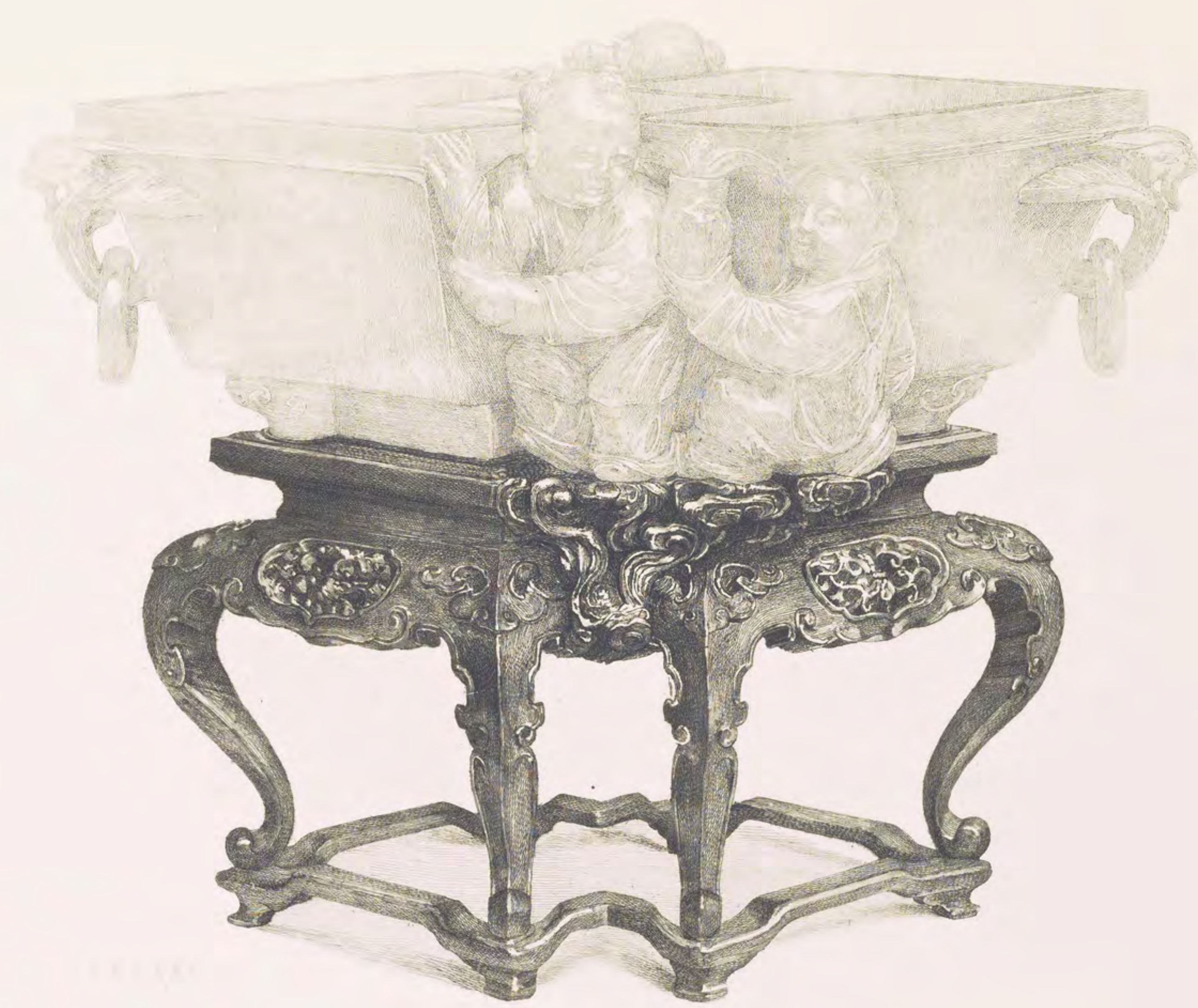
No. 367

ARTIST'S WATER-DISH

(*Pi Hsi*)

Ming Dynasty (1368–1644)

Nephrite



sand" with which the tools are kept constantly charged. The "jewel sand" used in China is generally derived from Oriental, or precious, garnets, such as are commonly called *almandin*, but ruby and sapphire sand seem also to be imported from Yunnan and Tibet for the purpose. It is very doubtful whether they ever use diamond dust. For polishing the surface there is a graduated series of wooden wheels, from fifteen inches in diameter downward, which are mounted upon a wooden spindle, and worked upon the reciprocal treadle-lathe that has already been described. For polishing the deeper interstices of the carved work there are small wooden plugs and cylinders fitting into the hollow end of the same spindle; the smallest are sometimes made of the dried skin of the bottle-gourd.

The final polish is given by a graduated series of wooden wheels covered with ox leather, stitched together with hempen thread. These "leather wheels," which are depicted in the illustration, No. 13, run from over a foot down to two inches in diameter. They are also mounted for work upon the wooden axle, and revolved upon the same treadle-lathe as the wooden wheels shown in the previous illustration, No. 12. To them, charged with "jewel sand" ground down to the utmost fineness, is due the unctuous aspect of the finished piece which is so dear to the lover of jade.

Reviewing for a moment the work of the Chinese craftsmen, it may be said that they possess all the methods known to modern jewellers and lapidaries. No new tools, in fact, seem to have been invented in the West. The chief improvement has been in increasing the rapidity of action of the old tools by the introduction of a continuous lathe, and by making it whirl more quickly by means of steam or electricity. A perfect sphere or cylinder may be produced by Russian machinery from Siberian nephrite, or large and gracefully shaped vases of simple form modelled in classical lines, like those exhibited at the last Paris Exposition; but it seems hardly fair to compare such mechanical triumphs to those of a humble Chinese artisan who has patiently labored for years at his lathe to shape, carve, and polish a single piece with the simple tools at his command. The personal element which gives a certain value to art objects is always wanting in machine work. The tools may seem to be rude, but greater finish does not always increase their efficiency. Steel is no better for cutting-wheels than iron, as the latter material holds the sharp sand, which is really the cutting agent, better than steel; and it has been found by experiment that tubular drills of elder, soft as it is, are, for the same reason, almost as efficient as those of metal for boring hard stone.

According to Mr. C. W. King, the Hindus were "the earliest perhaps of mankind to attain to mechanical perfection and facility in the carving of the hardest stones—the jade, agate, crystal, granite, etc.—into ornamental vases and other figures"; and he instances as examples the marvellous statuette of Buddha, about an inch high, carved out of one entire and perfect sapphire, a trophy from the sack of Kandy, now in the Mineralogical Department of the British Museum, and the large tortoise, nineteen inches long, carved in jade, which was found in a water-reservoir near Allahabad, now in the same museum, which is, he says, "for fidelity to nature and exquisite finish worthy of the ancient Greeks." India derived most of its knowledge of art and letters, directly or indirectly, from ancient Babylonia; and Mr. King is no doubt right in his suggestion that the cameo-workers of classical times also took their technique from the seal-cutters of Babylonia and Assyria. The common method of working was with the drill, or *tornus*, a tool with a blunt and rounded point, producing a succession of hemispherical hollows of varying diameter, which was worked by a hand-bow. Emery, a granular combination of corundum with iron, of black or grayish-black color, was employed very early; it was known as *smyrris*, according to Dioscorides, a name derived from the Hebrew *smir;* it is the Naxian stone of antiquity, its chief source of supply having been the Grecian archipelago, and it is still in modern times one of the principal productions of the island of Naxos.

A series of Indian cups and bowls of jewelled jade from Lahore was displayed in the London International Exhibition of 1851. They were inlaid with a gold setting and mounted with uncut rubies, sapphires, and other precious stones, the brilliant effect of which was enhanced by the soft sheen of the white, translucent jade in which the jewels were embedded. The official catalogue of the exhibition contains an account of the Indian methods of manufacture of jade and other hard stones, written by Mr. Augustus Summers, a resident at Cambay, from his own observations made on the spot. He says that rock-crystal and other varieties of quartz, cat's-eye, bloodstone, veined agate, lapis lazuli, carnelian, and chalcedony, were worked there into small objects of art and curiosity; and that vast quantities of beads, up to the value of sixty thousand rupees,

were exported annually from Cambay, by way of Bombay, to China, for the official rosaries worn in that country. The Indian lapidary first drives an iron spoke, named *khoredia*, into the ground in an inclined direction, with one point upward. Cups and saucers and any other hollow articles are placed on this point and chipped into shape to the required external form with a hammer. Square and angular objects have to be sawn into shape with a toothless hand-saw charged with emery-powder. They are then roughly polished with a coarse and hard polishing stone called *dholin*. The cavity is formed by the diamond-tipped drill to a depth of one fourth of an inch all over the space, until it exhibits a honeycombed surface; the prominent places round the holes are then chipped away. This process is repeated until the form and depth desired are obtained; they are then polished upon prepared moulds of convex formation and of the same composition as the polishing plates which are attached to the turning-wheel. The preparation of these polishing plates or dishes is described next: "The plates or dishes are made of emery (named *korunge* and *samadah*), a species of corundum of grayish-black color, glistening lustre, and granular concretion. Its fine powder is obtained by trituration and levigation, and this, mixed with the seed-lac, forms the circular polishing plates, two in number: the first, or coarse-grained, is made in the proportion of three parts of ground emery to one of lac; the second, or fine-grained, is made of two and a half pounds of finely levigated emery to one *seer* of lac. A third, or finest, polishing dish is composed of *warry* (powdered carnelian) and lac in equal proportions. A copper dish is occasionally used for very hard stone, such as the Ceylon and other precious stones, and a wooden dish, made of deal or some other fine-grained wood, is employed for polishing the softer description of stone."

An interesting account of the native Indian lapidary wheel is given in the same exhibition report, quoted from the "Bombay Times": "The wheel consists of a strong wooden platform, sixteen inches by six, and three inches thick. In this are two strong wooden uprights; between these is a wooden roller, eight inches long and three inches in diameter, fastened into a head at the one end; this works on an iron spindle or axle at each end. On the one end the axle is screwed and fitted with a nut, by which the cutting or grinding wheel can be made fast. The lap-wheels consist of two circular discs or cakes of lac with ground corund, coarse or fine according to the work; of a copper disc for polishing the very hard, and a wooden one for finishing the work of the softer description of stone. These are spun backward and forward by a bow, the string of which passes round the roller. The lapidary sits on his hams, steadying the wheel with his foot, and holding on the stone with his left hand while he works the bow with his right."

The technical methods of the Indian lapidary are remarkably similar to those of the Chinese, although his apparatus, as described here, is still more primitive in character. There is no treadle, while the Chinese craftsman spins his wheels with a reciprocating treadle worked by his feet, so as to have both his hands free for the lapidary work.

But modern Indian work in jade cannot compare in artistic value and finish with that of the time of the magnificent Mogul emperors of the seventeenth century, who were such liberal patrons of the decorative arts and had a peculiar traditional reverence for jade. There are many remarkable examples of this period in the Collection, numbered 755–787. Seven of the choicest specimens of jewelled jades are illustrated in the accompanying colored plate, where the two chief varieties of creamy white and sage-green so characteristic of Indian work in jade are well represented. In the old work only the most precious gems are used, notably the diamond, ruby, emerald, and occasionally the pearl; in the case of the bottle, No. 779, a striking effect is produced by inlaying thin plaques of fluted white nephrite on a dark sage-green background. In more recent work the sapphire, ruby, diamond, emerald, cat's-eye, coral, topaz or zircon, and turquoise are all used. The jewels are inlaid in floral and other designs by cutting out a space somewhat larger than the jewel itself and hammering fine gold into this space, the edge of the soft, ductile gold being turned over to fasten or secure the jewel. In most instances the jewels protrude above the jade itself, but in No. 779 all the metal-work has been ground off smooth, giving the effect of a damascened surface.

The methods of working jade in Persia and the other Mohammedan countries of western Asia, where it is wrought into hilts for swords, grips for daggers, talismans with inscriptions from the Koran and other mystical formulæ, are much the same as those employed in India. According to M. Al. Gayet, the author of "L'Art Persan" (Paris, 1895), some of the Persian carved stones, from the rarity of their material

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No. 778

JEWELLED DAGGER-HANDLE

India

Seventeenth Century

Nephrite

No. 769

JEWELLED DAGGER-HANDLE

India

Seventeenth Century

Nephrite

No. 779

BOTTLE INLAID WITH SILVER

India

Seventeenth Century

Nephrite

No. 770

JEWELLED ARMLET

India

Seventeenth Century

Nephrite

No. 772

JEWELLED BOWL

India

Seventeenth Century

Nephrite


PRANG · BOSTON ·

and the perfection of their sculpture, are worthy of being classed as jewels. Jade, agate, onyx, amethyst, turquoise, rock-crystal, carnelian, chalcedony, heliotrope, chrysoprase, and sardonyx are treated there with a sureness of touch which reveals a craftsman possessing every secret of the glyptic art. The jades are generally, he says, of a clear tint, either yellowish-white or pale green, and of varied tone, the latter being veined with olive-green and the former jaspered with shades of milky yellow. These different shades are especially apparent on objects of some importance, such as sword-hilts or flasks; but all pieces, large or small, show evidences of having been fashioned by a gradual working down of the jade by a process such as we have seen employed in India,—a regular drilling of little holes deepening the hollows and swelling the outlines. M. Gayet is inclined to think that the Persians were the pupils of the Chinese craftsmen in the art of carving jade, but the process he describes so eloquently seems to be rather that of the Indian lapidary, and it may perhaps be traced back, as has already been remarked, to the ancient seal-cutters of Babylonia and Chaldea.

It could only have been by a very gradual course of development and improvement that the Chinese, Persians, and Indians could attain such facility in the working of jade. The prehistoric people of remote neolithic ages who used nephrite, jadeite, and chloromelanite for the manufacture of their primitive tools and weapons had certainly, as will be seen presently, no mechanical apparatus of the kind at their disposal. Nor had the modern jade-using savages, such as the natives of New Zealand, New Caledonia, and other islands of the South Sea, and the aborigines of Alaska and British Columbia, who at the time of their discovery had hardly advanced beyond the stage of culture of the ancient neolithic tribes of France and Switzerland. The best account of their methods has been sketched by Sir John Evans in his "Ancient Stone Implements," where he precedes his description of the implements themselves by a general account of the more usual processes adopted in the manufacture of stone implements in prehistoric times. The justice of his conclusions, which were generally tested by personal experiments, has been confirmed by those of subsequent observers. Jade was too tough a material to be fashioned into shape by chipping with a stone pick or hammer, like ordinary stone weapons, so that the original block had to be first cut up with a sharp saw-like tool. Dr. Keller found that many of the nephrite celts discovered in the Swiss lake-dwellings showed evident traces of having been partially fashioned by means of sawing. The block of nephrite is supposed to have been sawn, either with or without sand, by means of flint flakes, and possibly also of strips of hard wood or bone used in conjunction with an abrasive. The sides and edges of the celt thus sawn out were then ground down, the grindstone on which they were polished being fixed and not rotatory; the striæ running along the stone hatchets are generally longitudinal, proving that they were rubbed lengthwise and not crosswise on the grinding-bed; sometimes rubbers of stone were also used, probably in conjunction with sand.

These methods have prevailed among the more primitive jade-using tribes up to recent times, as, for example, in New Zealand, Alaska, and British Columbia. Dr. G. M. Dawson, Director of the Geological Survey of Canada, says of the last: "The peculiar adaptability of jade to the manufacture of implements is shown by the mode of working it which has been in use by the natives, which is clearly indicated by specimens from different parts of the whole region from the Fraser River to the Arctic Sea. A suitable fragment having been discovered, it has evidently been carefully sawn up into pieces of the required shape and size, the sawing having been effected either by means of a thong or a thin piece of wood in conjunction with sharp sand. This rude method of dividing the stone must have been very laborious, and produced a widely gaping cut before great depth was obtained. From the fragment of a boulder obtained at Lytton flat pieces intended for adzes have been sawn off, the cut having been carried in from the surface, on each side, till it became possible at length to break the central rib by which the piece to be detached was still united to the main mass. The boulder from Yale shows the same process in an earlier stage, deep cuts having been made on both sides of the stone. Several of the adzes or chisels show that the same method of sawing was adopted to trim off the edges of the flat pieces first obtained, and to render them parallel-sided. Pieces thus cut from the edges are represented among specimens from graves near Lytton. Having been thus roughly blocked out by sawing, the surfaces of the adze were next generally ground flat. In the more finely worked specimens subsequent grinding has almost or altogether obliterated the original shaping furrows, and the surfaces have eventually been well polished."

The processes of sawing nephrite in New Zealand in the manufacture of aboriginal implements are splendidly illustrated in the Collection by the divided hatchet, No. 288, and the partly worked water-worn block, No. 299, which will be described presently. Both pieces are illustrated by pen-and-ink drawings in Volume II.

The perforated nephrite axe is a higher development of the ordinary celt, and the shaft-hole, as we shall see presently, must have been bored in many different ways, by means of a hand-drill of some form or another, either whirled by the palms of the hands, or kept in rotatory motion by a cord or strap. The "fire-drill," for producing fire by friction, which was in use in most parts of the ancient world, would have furnished the earliest pattern for such a drill. The most primitive drill was the straight shaft, revolved between the outstretched palms of the hand; the strap or bow drill was an improvement on the shaft worked by the hands; the pump drill, a further development of the bow drill. The bow drill in Asia and in northern Africa is traced back by Mr. McGuire, in his paper already quoted, to a period as early as the first monuments of these countries; he refers the strap drill to a similar mechanical period; and finds the pump or disc drill, which owes its origin to Egyptian culture, depicted among hieroglyphs of the fourth dynasty. He can discover no reference to any one of these drills by any early traveller in America, and he concludes therefore that the aborigines of America used only the plain shaft drill, although, he says, it might naturally be supposed that a people possessed of bows and arrows would have discovered the principle as well as the uses of the other drills.

The primitive shaft drill is often pictured on ancient Mexican codices, being rotated between the palms of the operator for the production of fire. The Mexicans showed great skill in boring cylinders and ornamental objects of jadeite, rock-crystal, and other hard stones, and they seem to have employed drill-points of tubular metal, probably copper, as well as of reed, to tip their shaft drills. An examination of a number of jade figures and objects from Oaxaca showed, as Mr. McGuire reports, that holes, one sixteenth of an inch or less in diameter, were bored in the hardest stones, the bottoms of which had conical projections, indicating clearly the use of a tubular drill. At other points, however, he says that the small holes had been bored with solid points, probably of copper carrying grit. One little head of nephrite from Tasco el Viego, illustrated by him (Fig. 43), "clearly shows the employment of a metal drill of tubular form, and also one having a solid point. The ears have been designated by means of a depression made by a tubular drill having a shallow core not one fourth of an inch in diameter; yet in this small space a still smaller tubular drill has made a depression, leaving a cone in its centre little more than half the diameter of an ordinary pin's head. The eyes are similarly bored, and on the back of the head, on either side below the ears, small holes, an eighth of an inch in diameter, have been bored at an angle to each other, as shown by the dotted lines in the figure, until they meet at the point of intersection, thus allowing strings or wires to be passed through the holes for purposes of suspension."

This description has been quoted in full to show how much may be gathered from the careful inspection of a single specimen of old handiwork. An examination of the Mexican amulet of jadeite, No. 309, which is illustrated in the colored plate, will show clear evidence of the work of both kinds of drill, tubular and solid. The eyes of the serpent have been bored with a large tubular drill, leaving central cores to be subsequently polished, while the holes for stringing the amulet in a necklace and for hanging pendants upon it have been pierced by solid points. See also the mask, No. 303; the long tubular bead, No. 306; and the bird's head, No. 308, in the same plate, which will be again referred to later.

Jade has always been worked in the same lines as other hard stones, and Mr. Kunz, an expert in the art, has lucidly summed up the connections of ancient and modern lapidary craft in his work "Gems and Precious Stones," as follows:

"The chipping of an arrow point, the grinding and polishing of a groove in an axe head, the drilling of a bead or tube or an ear-ornament, all were done by the application of the same lapidarian methods that are practised to-day by cutters of agates or precious stones. The cutter of to-day, with hammer, chips into shape the crystal or piece of agate before it is ground; and there is little difference between the ancient method of drilling and that of the present. The stone bead of ancient time was drilled from both ends, the drill holes often overlapping or not meeting as neatly as by the modern method of drilling from one end.

"The old way of drilling is still practised in the East, where the primitive bow drill is used by lapidaries

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No. 463

DUCK

(*Ya-tzŭ*)

K'ang-hsi (1662–1722)

Nephrite

to-day precisely as it has been used by savage tribes in all quarters of the globe, though producing at different periods different qualities of work. Nowhere was its use better understood than in ancient Greece and Rome, where, by its means, were engraved the wonderful intaglios and cameos which now grace our museums, and which have never been surpassed in any period of the world's history. For the special use of gem-engraving, the bow drill has been replaced by a horizontal lathe, which, however, does not allow the freedom of touch or softness of feeling which artists attained by use of the bow drill. The instrument known as the dental drill is really an improved form of bow drill, working much more rapidly. A dental engine provided with a suitable series of drill-points answers every purpose, and has been found especially useful in exposing fossils and minerals when covered with rock, the objects being opened with great rapidity, with little danger of injury. As shown by the writer in a paper on a new method of engraving cameos and intaglios, an artist could be so trained to the use of this improved bow drill as to attain the same softness and feeling developed by the old lapidarian masters.

"In the ancient specimens of work, tubes from which a core had been drilled out by means of a reed and sand, revolved by the hand, were done as neatly as anything can be done, the reason being that the object was entirely drilled from end to end. This method of drilling is still practised, except that the hollow reed is replaced by the diamond or steel drill. When a valuable stone is being drilled, a sheet of steel or a thin iron tube is substituted for it. The polishing and grinding now are done on rapidly revolving discs, horizontal or lap wheels, as they are called, whereas formerly the slow process of rubbing with the hand on board or leather was perhaps resorted to. No lapidary can do finer work than that shown by the obsidian (and jadeite) objects from Mexico, the labrets, ear-ornaments, and tubes, which are even more highly polished, though no portion of the circle is thicker than one thirty-second of an inch.

"Many of the aboriginal stone objects found in North America and elsewhere are marvels of lapidarian skill in chipping, drilling, grinding, and polishing. Few lapidaries could duplicate the arrow points of obsidian from New Mexico, or those of jasper, agate, agatized wood, and other minerals found along the Willamette River, Oregon. No lapidary could drill a hard stone object truer than some of the banner-stones, tubes, and other objects made of quartz, greenstone, and granite that have been found in North Carolina, Georgia, and Tennessee, or make anything more graceful in form and general outline than are some of the quartz discoidal stones found in these same States. These latter objects are often four to six inches, and occasionally seven inches in diameter, ground in the centre until they are of the thinness of paper and almost transparent, and the great regularity of the two sides would almost suggest that they had been turned in a lathe. This may have been accomplished by mounting a log in the side of a tree so that it would revolve, and cementing the stones with pitch to the end of the log, as a lapidary would do to-day at Oberstein, Germany, or by allowing the shaft of the lathe to protrude through the side of the log, and cementing the stone to be turned on this. The Egyptian wood-turner at work in the Rue de Caire at the World's Fair, Paris, 1889, might, with his lathe, polish a large ornament of jade or jadeite like the masks, idols, tablets, and other objects found in Mexico and Central America, or the jade knives from Alaska."

After this cursory review of the principal instruments employed in the manufacture of jade objects at different times, and in various countries, we may proceed to a short survey of the Collection for further illustrations of the branches of work, beginning with the earliest and most primitive methods.

Our knowledge of the processes used by prehistoric man in fashioning his tools and weapons is derived from two sources:

I. A study of the objects themselves.

II. The recorded observations, in comparatively recent times, of the methods used among the uncivilized races of the world, as, for example, in the South Sea Islands and among the Indians of Alaska and North America generally.

New Zealand Methods

In New Zealand the working of jade existed until so recent a date that definite and minute descriptions of it have been given by travellers, missionaries, and European residents, derived from their own observations or

from the accounts of aged natives. New Zealand seems to have been first visited by Tasman in 1642, but the first to explore the islands was Captain Cook, who independently discovered the country in 1769. It was declared a dependency of New South Wales in 1814, and a missionary was appointed a resident magistrate by the British government, but no effort was made to colonize it until 1825, and that was unsuccessful. It is probable, therefore, that Maori methods of working jade at that time differed but little, if at all, from the methods employed by them and by early man in working other stones, except that, as we have already seen and stated, the toughness of the material rendered impossible the methods of flaking and chipping so familiar in the making of implements from silicious stones or obsidian.

Pebble Forms

In the earliest stages of the neolithic period quarrying would be unnecessary. In the very nature of things, sharp angular fragments of all sizes, and rolled pebbles, must have been abundant. In the case of the former probably little was required to be done except to adapt the fragment to the hand, while the rolled pebble would often require nothing beyond giving it a sharp edge. Keller tells us ("Lake Dwellings," Vol. I, p. 269) that at Concise and Meilen in Switzerland a large number of the finds were merely sharpened pebbles, and the Collection furnishes many similar examples. No. 192, a small knife from Lake Neuchâtel, illustrated in color, was evidently fashioned in this way ; and it will be seen at a glance that the illustration of the thin Sann pebble, Cast A, required nothing but a cutting edge to make it an effective tool, and to make it more shapely the grinding away of a small projecting shoulder at one side would suffice. This pebble is paralleled by several in the Collection from China and the Jade Rivers of Turkistan. Among these Nos. 66*b*, 60*e*, and 60*l* may be mentioned.

Cleaving

When loose angular fragments or natural pebbles were not at hand and only large blocks or boulders were available, several different operations became necessary. The first was the preparation of the material. We have no evidence that prehistoric man ever resorted to the use of fire in splitting rocks, as the jade-miners of Burma do at the present day. Stone hammers had therefore to be used to fracture the mass. Those used for this purpose by the aboriginal New Zealanders were conveniently shaped boulders about the size of a man's head. They were of trap or quartz or similar stone, and were usually fitted with wooden handles. In order to guard against cracks, a deep groove was sometimes cut in the piece to be broken before striking the blow. This splitting process is comparatively easy in the case of nephrite, owing to its characteristic schistose slaty structure, which permits the mass to be cleaved into flat pieces along its line of bedding. It is probable that this was the only method used in reducing such large masses, as sawing would involve the expenditure of more time and labor than even prehistoric man, with all his time and patience, could afford.

Battering

When a suitable piece was found, the next operation was the shaping of it. In some cases this was done by bruising[1] or battering it with a smaller stone hammer. The Collection possesses several specimens that were entirely battered into shape. They are very rude in form and show either the fractured surface or the natural boulder-marks. Some were hammered into approximate shape and then ground, as, for example, No. 200, a hatchet from Lake Constance; No. 188, a chisel from Lake Neuchâtel; and No. 207, a hatchet from Brittany, France.

Grinding

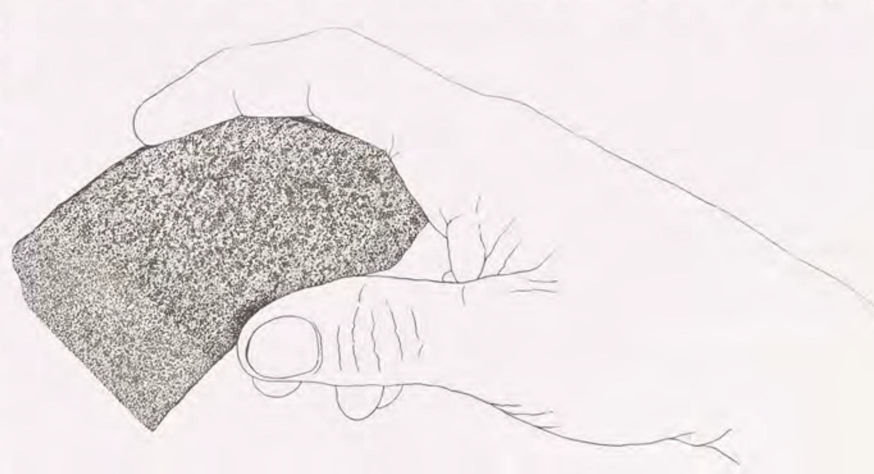
Grinding was one of the commonest processes resorted to by early man. The tools used in the process seem to have been pretty much the same everywhere. Keller figures grindstones of sandstone found in the remains of Swiss lake-dwellings, and several varieties of sandstone are mentioned by Chapman as

[1] Chapman, Transactions of the New Zealand Institute (1891), p. 512.

having been used in New Zealand. One variety greatly used there was called *hoanga*, and the commonest form seems to have been that of a large block held between the feet, the object to be ground being passed back and forth on it, water being supplied from a calabash or the like suspended above it. A fine specimen of *hoanga* is labelled 20,285 in the Archæological Museum of the University of Pennsylvania. Smaller grind-stones were used in the hand. The Rev. Mr. Stack, one of the early missionaries quoted by Chapman, says that when a native found a suitable piece of stone for the article to be made he placed it either on the ground or on a slab of wood cut to fit it and rubbed it with a *hoanga*, the greenstone being kept continually moistened with water.

Sawing

Sometimes objects were first sawn into shape. We have innumerable examples of this process. It was accomplished in New Zealand by means of a sharpened slab passed back and forth saw-fashion. Chapman, in his essay "On the Working of Greenstone" in the "Transactions of the New Zealand Institute" (Vol. XXIV, 1892), a rich mine of information regarding jade and jade-working in New Zealand, tells us that thin slabs of wood were often used with wetted sand; and the same writer quotes Major Heaphy, who in 1848 observed the Maoris of the Middle Island using thin pieces of sharp quartzose slate worked saw-fashion with water. The material used, however, seems to have been varied, and was known by a variety of names. Shortland (quoted by Chapman) gives a long list, mentioning among them a kind of sandstone called *mania*, which he describes as a "soft cutter." The "hard cutters" were made of trap or some similar rock. Chapman also speaks of flint and wet sand being used. There is in the Collection a cutter of gritstone that had been used by the aborigines of British Columbia, and is shown in the accompanying illustration.



It appears to have been difficult for prehistoric man to saw a stone clear through from one side so that the pieces would fall apart. It was usual, therefore, to perform this operation by cutting from opposite sides, the uncut portion left in the centre being afterward broken by a smart blow, leaving rough edges which had to be ground away later.

This method of sawing is abundantly illustrated in the Collection. One of the best examples is No. 288, the divided hatchet from New Zealand, already mentioned. In this specimen the irregularities of the ragged projecting edges of the broken core fit into each other with great exactness. Another good example is that shown in the illustration of Cast Q, a long New Zealand or New Caledonian flat hatchet, 14 inches long 0.87 inch thick, which was undoubtedly part of a large flat slab, from which it was separated by partial sawings from two faces, and a blow. The rough edges left by the fracture are still very prominent. Other examples that may be mentioned are No. 247, from Alaska; No. 228, an axe from British Columbia; and No. 235, a chisel from the same locality. In some instances the fractured core is quite thick. In No. 243, a very rough Alaskan adze, the fractured core is fully three quarters of an inch thick, and must have required a very severe blow to break it. The core of No. 278 is five eighths of an inch thick. In other cases again it is very thin, as in No. 241, a large axe from Alaska, and No. 268, a little flat triangular knife from the same locality. In a large number of other cases both the saw-marks and the rough edges have been entirely obliterated by grinding, or only faint traces remain, as in No. 249, a well-formed Alaskan adze.

This method of sawing seems to be characteristic of New Zealand, the Bering Sea coast of Siberia, Alaska, British Columbia, Mexico, and Central America. Traces of the sawing operation are rare elsewhere, being found only on some five or six specimens from the lake-dwellings of Europe. It does not follow from this that sawing was an uncommon process with the prehistoric inhabitants of Europe. It may only mean that traces of sawing have been obliterated.

One of the most interesting examples of sawing in the Collection is furnished by No. 299, a large stock-piece from New Zealand, showing as it does several ground facets and saw-marks, and especially an arrested

attempt to remove a long piece, 14 centimetres in length, and 2.25 centimetres in breadth at top, probably for a *kuru*, or ear-drop. The grooves made by sawing are 15 millimetres in depth, and a very little further cutting would have sufficed to separate this *kuru* blank from the mass. Both grooves are curved, thus roughly outlining the ultimate contour of the finished ear-drop, and both are wide, owing in part probably to the play of the cutting-tool and partly to its bluntness. Its edge was probably not wider than three to three and a half inches. The block itself is nearly 28 centimetres in length, 10.6 centimetres in breadth, and 5.1 centimetres in thickness.

It is interesting to note what Hochstetter says in regard to the shaping out of these ear-drops. "When an ear-drop is to be made, a straight piece of wood is tied with flax on the piece of nephrite that has been selected. A piece of flinty slate is then rubbed along the wood up and down, the nephrite being kept wet. It takes several days, often a week, before the cut has been made."[1]

It is known that strings or thongs have been used with water and an abrasive in stone-cutting, but this method is not exemplified by prehistoric specimens in the Collection. The same remark applies to wire, the use of which the Maoris soon learned after coming into contact with Europeans. It is evident that the cutting-tool of the prehistoric workman was of firm material and had a straight cutting edge. Quite a large number of specimens illustrate this point. One of the best is No. 298, an irregular four-sided slab from Guatemala, from the centre of which a round piece had been cut, apparently by a hollow cylindrical drill, before the slab itself was removed from the larger block of which it had formed a part. This was done by six sawings in six different directions, and so carefully executed was the operation that only two tiny unsawn portions remained to be fractured when the slab was detached, leaving a cylindrical projection on the original mass. It is evident that the care shown in the sawing was prompted by a desire not to mar this projection with saw-marks. The marks on the under side of the slab are remarkable for their straightness and regularity, showing that a rigid body had been used—perhaps a sheet of copper, as this metal was known and in use in Mexico long prior to the Spanish conquest. Its softness made it a good matrix for the abrasive used. Other specimens in the Collection show similarly regular straight cutting marks, notably No. 179, a small hatchet from Lake Neuchâtel.

Many specimens in the Collection show that they had been shaped entirely by grinding, a process which has already been fully explained. No. 233, a hatchet from British Columbia; No. 171, a knife from Switzerland; No. 208, a hatchet from Alzonne, France; and No. 285, a flat axe from New Zealand, may be mentioned. Several specimens still show marks of the fine abrasive used.

Polishing

After chipping, grinding was probably one of the earliest processes used by man, and it was the only process possible in producing the sharp edge he needed in his various industries. The smoothing and polishing of the completed implement were also accomplished by grinding and rubbing, the material of the polisher being probably some finer-grained mineral than that used in the process of grinding into shape. Polishing stones for use in making the jade musical stones are mentioned in the oldest historical records of the Chinese as forming part of the tribute paid by certain western regions, but the nature of the stones is not mentioned. Wherever neolithic stone implements have been found in Europe, polishing stones have also been found. Chapman says that in New Zealand micaceous slate was used. When travelling, a Maori would take with him the object he was working on and some slate, and at every halt a rub would be taken at it. A native would get up at night, he says, to have a polish at a favorite *meré*, or take it down to the sea-beach and work away by the surf.

Pecking

Implements thus polished and intended to be mounted in a handle or holder were afterward roughened by hammering or pecking on the sides or near the head, the better to secure the tool in its mount. The Collection furnishes numerous examples of this pecking, some of them with handles. A study of these seems to

[1] Hochstetter, On the Occurrence and the Different Varieties of New Zealand Nephrite (1865).

Forbes Boston

No. 303
SMALL MASK
Jadeite
Mexico

No. 281
HATCHET
Nephrite
Eastern Coast of Siberia

No. 306
LONG TUBULAR BEAD
Jadeite
Mexico

No. 309
AMULET
Jadeite
Mexico

No. 295
WEAPON
(*Nas-cah*)
Nephrite
British Columbia

No. 308
ORNAMENT
Jadeite
Mexico

No. 283
KNIFE
Nephrite
Eastern Coast of Siberia

No. 247
ADZE IN HOLDER
Nephrite
Alaska

No. 234
CHISEL
Nephrite
British Columbia

No. 282
CHISEL
Nephrite
Eastern Coast of Siberia

No. 280
ADZE
Nephrite
Eastern Coast of Siberia

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show that the process was peculiar to the Swiss lake-dwellings and to France. Not a single instance is found among those coming from China, New Zealand, Mexico, British Columbia, Alaska, or the Bering Sea coast of Siberia. In the three last-mentioned localities, and sometimes in the lake-dwellings of Switzerland, the same purpose seems to have been served by utilizing the natural roughness of the implement, as in No. 197, a knife with a deer-horn handle from Lake Bienne, which still retains the roughness of the original mass, and No. 247, an adze from Alaska set in a rough-shaped walrus-bone handle. These two specimens illustrate very clearly the difference in mounting of the two localities. In Switzerland deer-horn was used for holders, and was probably fitted upon the head of the implement while green, or secured there by pitch. In Alaska and British Columbia bone or ivory was used, the rough head of the tool being secured in the bone after it had been softened by boiling, the natural contraction due to cooling giving it a firm grip.

Among the mounted specimens from the Swiss lake-dwellings that exemplify this pecking the following may be mentioned: No. 172, a hatchet from Neuchâtel, roughened by pecking on the sides and near the top, which is set in a polished deer-horn holder, shaped at the upper end to fit into a handle or haft; No. 188, a small hatchet from the same locality; No. 196, a knife from Lake Bienne; and No. 168, a small hatchet in deer-horn holder.

Among the unmounted ones attention may be directed to No. 176, from Lake Neuchâtel; No. 202, from Lake Constance; and from France, No. 207 from Brittany, No. 212 from Authon, No. 209 from Alzonne, and No. 213 from Puylaurens.

Drilling

The perforated prehistoric objects in the Collection are comparatively few in number—less than a score and a half. They are all polished and come mostly from Mexico and Central America. China and New Zealand come next; then Alaska with two specimens; and a solitary one from the Bering Sea coast of Siberia—which may be Alaskan—and one from New Caledonia. There is a cast in the Collection, O, a chisel-shaped hatchet, the origin of which is uncertain. It is said to have been found in Estremadura, Spain, and Meyer claims that it is of Spanish origin, but Fischer that it is Mexican, basing his claim on the fact that it is perforated. Cartailhac is of the opinion that it is not European. Perforated stone implements are mentioned by Keller as having been found in the Swiss lake-dwellings, but none of these pierced objects are of jade, and the perforations seem to be confined exclusively to haft-holes. Not one of the German hatchets represented in the Collection by casts is perforated.

In considering this part of the subject two things are to be noted:

First. The nature of the perforations themselves.

Second. The methods and tools used in making them.

Nature of the Perforations

Three different kinds of perforations are exemplified in the Collection: (1) Those which form part of a shaping operation, as in forming the arms and legs of the New Zealand *heitiki*, No. 315; the tubular part of the trumpet-shaped Mexican ear-ornament, No. 307, already described; and the small Mexican pendant in the form of a bird's head, No. 308. (2) Perforations made to assist in mounting an implement or weapon, as in the New Caledonian battle-axe, No. 297. (3) Those intended for suspensory purposes. This is the largest class, and is composed almost entirely of amulets and ornaments, the chief exceptions being the small knife, No. 283, from the Bering Sea coast of Siberia (or Alaska); the two hatchets from China, Nos. 292 and 293; the cleaver from China, No. 294; and the New Zealand *meré*, No. 296.

Some of the perforations are made direct through and through, drilling from one face or side, the aperture on one face being wider than on the other, owing to the wearing away of the borer as the work proceeded, or to the shape of the borer itself. This is exemplified in the Chinese and Alaskan pieces already mentioned; in the falcon's head, No. 308, from Mexico; and in the two small Guatemalan tablets, Nos. 300 and 301. In

other specimens the drilling has been done from two opposite sides or faces, the meeting point being narrow and the external apertures wide and crater-like, the whole perforation presenting the appearance of two hollow truncated cones connected at the apices. This method is exemplified in No. 297, the battle-axe already referred to; No. 303, the little Mexican mask; the five-lobed Mexican bead, No. 305; and many others. In No. 306, the long Mexican bead, the diameter of the perforation is almost uniform throughout; and the Japanese *magatama*, No. 347, classed with the tomb pieces, is as perfectly and evenly drilled as if done by a modern lapidary.

A further remark may be made regarding these perforations. Some are submarginal, others subsurface or "subcutaneous." In the former case the drilling is begun on one face, near a corner or edge, and carried a certain distance, when it meets a similar drilling at an angle of 90°. This is well illustrated in the *heitiki*, No. 315, which is perforated at the top in this way for suspension round the neck. A still more excellent example is the Mayan amulet, No. 309, with no fewer than eleven perforations of this kind around the edge, and two subcutaneous perforations formed by drilling at an acute angle in two opposite directions on the same face until they meet. In this specimen both of these kinds of perforation are not for the suspension of the piece (this is also provided for), but for suspending the small ornaments with which Mexican idols are frequently decorated. These were of jadeite, obsidian, amethyst, and the like, and are frequently found in ancient Mexican graves.

The Drill

The drill employed in making these perforations was usually a sharp-pointed hard stone of some kind, such as flint, obsidian, trap, and the like. Dr. Shortland, one of Chapman's correspondents,[1] states that in New Zealand a sharp-pointed stick of soft wood was used with sharp, biting sand and water. Hochstetter,[2] who visited New Zealand at a later date (about the middle of the nineteenth century), says that perforations were made with a piece of flint or chalcedony tied to a round stick, which was twirled as fast as possible between the hands in the same manner as he had seen the natives of the Nicobar and Caroline Islands make fire with two pieces of wood of different hardness. A more elaborate contrivance is described by Chapman (p. 499) as in use by the Maoris: "A sharp piece of flint is set in the end of a split stick and lashed in very neatly. The stick is about fifteen to eighteen inches long, and is to become the spindle of a teetotum drill. For the circular plate of this instrument the hardened intervertebral cartilage of a whale is taken. A hole is made through this, and the stick firmly and accurately fixed in it. Two strings are then attached to the upper end of the stick, and by pulling them a rapid rotary motion is given to the drill. When an indentation is once made in the *pounamu* (nephrite) the work is easy. As each flint becomes blunted it is replaced by another until the work is done." White, author of the "Ancient History of the Maori," and the owner of a large archæological collection which includes over six hundred greenstone objects, is quoted by Chapman (p. 511) as stating that the Maoris in his neighborhood substituted two stones for the disc.

As Sir John Evans remarks,[3] "The use of a drill in some form or other, to which rotary motion in alternate directions was communicated by a cord, is of great antiquity. We find it practised with the ordinary bow by the ancient Egyptians, and Ulysses is described by Homer as drilling out the eye of the Cyclops by means of a stake with a thong of leather wound round it, which he pulled alternately at each end like a shipwright boring timber."

That hollow reeds, tubes of elder, and the like seem to have been used, we have evidence among the stone implements of the Southern United States at some pre-Columbian period; and Keller[4] found in some of the stone implements of Meilen partial borings at the bottoms of which projecting points had been left standing, indicating the employment of some kind of tube as the boring tool. This method has long been in use in China, and McGuire[5] reproduces a drawing from Petrie of an Egyptian example of a tubular drill-hole in granite.

[1] Transactions of the New Zealand Institute, 1891, p. 515.

[2] The Occurrence and the Different Varieties of New Zealand Nephrite, 1865.

[3] Ancient Stone Implements (1872), p. 44.

[4] Lake Dwellings of Switzerland (1878), I, 25.

[5] A Study of the Primitive Methods of Drilling (Washington, D.C., 1896), p. 652.

A somewhat remarkable example seems to be afforded by No. 298, an irregular four-sided slab of Guatemalan jadeite from which a round piece had been cut, apparently by a hollow cylindrical drill, before the slab itself had been removed from a large block which was being fashioned into some sort of vessel. The aperture measures on the rough surface 1.625 inches in diameter, and on the under side 1.5 inches. This example differs from that observed by Keller in the fact that the drilling does not seem to have been for the purpose of forming a hollow perforation, but for the purpose of forming a cylindrical projection on the block that was being worked upon. The specimen itself furnished no evidence regarding the material of the tube employed. It may possibly have been of metal, as the finder states that in a cave about twelve feet below its finding-place on Mount Tacana both stone and copper tools were found. We know that Mexico and doubtless also Guatemala had reached the copper age when America was discovered.

The Cakchiquels who inhabited this part of Guatemala belonged to the cultured Mayan stock of Yucatan, and were related to the Tzentals of Chiapas, already mentioned in connection with No. 309.[1]

[1] See Brinton's Annals of the Cakchiquels (Philadelphia, 1889).

PART V

WORKED JADE


PRANG · BOSTON

No. 428

QUADRANGULAR INCENSE-BURNER

(*Fang Ting Lu*)

K'ang-hsi (1662–1722)

Jadeite

No. 358

CUP (ONE OF A PAIR)

(*Ch'a Kang*)

Ming Dynasty (1368–1644)

Jadeite

No. 359

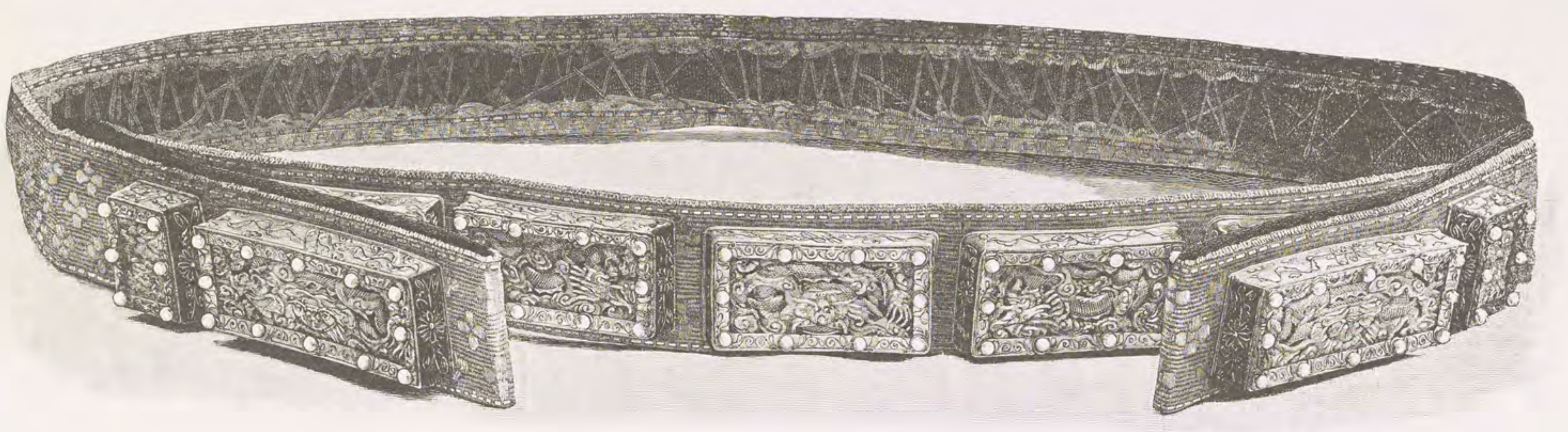
CUP (ONE OF A PAIR)

(*Ch'a Kang*)

Ming Dynasty (1368–1644)

Jadeite

519



WORKED JADE

IN Part III, under the superintendence of Mr. Kunz, jade has been considered as a mineral substance, and apart from the uses to which it has been put by man, though many worked specimens, some of them of rare artistic beauty and value, as well as many of ruder form and workmanship, were referred to. In Part II both Dr. Bushell and Mr. T'ang have touched upon some of the uses to which jade has been put in China; but even that part of the subject is worthy of fuller treatment, and in the pages which follow it is proposed to consider the whole subject somewhat in detail, in connection with the products of man's industry and skill which make up the Collection. In Part IV the methods of working jade have been described, and we now pass on naturally to give an account, under the heading of "Worked Jade," of some of the objects fashioned by these methods of working.

These may be divided into two great classes, each with several subdivisions:

I. The relics of the savage and barbarous peoples classed as prehistoric: *i. e.*, who lived prior to the beginning of history in their several localities.

II. The ornate and artistic specimens of the lapidary's art, the product of civilized peoples in historic times.

This arrangement is more convenient than scientific, but it will conduce to brevity and clearness in statement.

I. PREHISTORIC

The Stone Age

THE part of our subject which falls under this heading takes us back to the Stone Age of the world, when man, at least in the earliest stages of his existence, lived in gravel-pits and caves, in a nude or semi-nude condition, dependent for sustenance on the natural fruits of the earth or the flesh of such animals as he felt

himself able to tackle, or such as had fallen in combat with other equally wild animals. He was a creature of many needs, poorly equipped for the struggle of life, but with abundant opportunities for enterprise and invention, and for the development of whatever natural ability or mental powers he possessed.

It is no part of our purpose to discuss the duration of this earliest period of human life on the globe, nor to speculate in regard to the epoch in geologic time when it began; nor are we concerned with the origin of man, or the particular part of the world in which he first appeared. We find traces of his presence on the earth in very remote times, long before the dawn of history in even the oldest nations, and we take him as we find him. He needed tools and weapons in his struggle for existence, and experience, the great teacher of all times, taught him what materials were best adapted for his purpose and how best to fashion them into suitable implements. Stocks and stones were his stand-by for many a long day, and we learn now, from a study of the many objects he has left in the caves in which he sought shelter, or which he lost in the earth, or which fell through the flooring of the pile-dwelling he occupied, or which he buried with his dead, just how he waged war on nature and adapted himself to his environment, increasing, no doubt, as time went on, in comfort and culture, and in ability to cope with the conditions which beset him.

Its Divisions

This stone-using age has been divided by archæologists into a Palæolithic, or "ancient," stone age, when methods and forms were crude and appliances few, and a Neolithic, or "newer," stone age, the age of polished stone, when man had made some progress and was able to use harder and more costly material requiring more skill and more labor in its working, but doubtless giving better service than that used in the earlier period. It is to this later, or neolithic, age that the use of jade is assigned. The Collection therefore contains no specimens that could be assigned to the palæolithic period, and we are not concerned with it except in so far as it throws light on the general condition of mankind at and preceding the dawn of the neolithic period. It is best studied in western Europe, especially in France, and was established about 1860 as a great division of the Stone Age through the labors of M. Boucher de Perthes and others, being based chiefly on the finds made by the former in the river-drift gravel-beds of the Somme, the Seine, and the Oise. Similar finds under somewhat similar conditions were made in England, and, after much controversy, a Palæolithic division and a Neolithic division of the Stone Age have come to be generally accepted by both geologists and archæologists.

The Palæolithic Period

Rude though it was, the palæolithic period was an age of progressive change. At first man ran wild, without clothing or shelter, in the hot, moist climate which then prevailed, and had for his companions the deer, the hippopotamus, the *Elephas antiquus*, and the rhinoceros. In course of time the climate changes, cold and wet taking the place of the heat and humidity of the earlier stage, and a glacial period begins. Man retreats for protection to the caves, where the cave-bear, the hyæna, the Irish elk, the mammoth, and other great mammals bear him company. As the cold increases the reindeer and other arctic animals appear, the wild horse occurs, but the rhinoceros disappears; chippings of flint begin to be used as spear-heads, and horn, bone, and ivory come into use. The rigors of the Ice Age make covering for the body necessary, hence we find rude flint scrapers for dehairing and softening skins, and knives for cutting them; and awls and sinew-thread for fashioning them into clothing come into use. The reindeer increase in number, the urus appears, and flint continues in use; but the use of bone, horn, and ivory increases and the beginnings of decoration are noticeable.

During all this period man's cutting implements were mostly made of stone, principally flint sharpened by chipping or flaking, the arts of grinding and polishing being as yet unknown.

With the gradual passing of the Ice Age the earth becomes more habitable, the reindeer and other arctic animals migrate northward or upward with the receding cold, the caves are gradually relinquished as shelters,

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No. 196
KNIFE IN HANDLE
Jadeite
Lake Bienne

No. 181
HATCHET
Nephrite
Lake Neuchâtel

No. 183
HATCHET
Nephrite
Lake Neuchâtel

No. 192
KNIFE
Nephrite
Lake Neuchâtel

No. 197
KNIFE IN HANDLE
Nephrite
Lake Bienne

No. 186
CHISEL
Nephrite
Lake Neuchâtel

No. 198
HATCHET
Nephrite
Lake Constance

No. 194
KNIFE
Nephrite
Lake Neuchâtel

No. 180
HATCHET
Nephrite
Lake Neuchâtel

PREHISTORIC IMPLEMENTS FROM LAKE-DWELLINGS OF SWITZERLAND

fishing and hunting become more general, the range of communication is extended, man roams further afield, and discovers many new materials and new sources of supply; he comes into contact with other tribes or communities and learns from them; gradually nomadic life is abandoned, settlements are formed in desirable spots, agriculture is introduced, and domestic animals appear. Flint-chipping continues, but the workmanship is better; the arts of grinding and polishing are discovered; and man enters on a new era of progress,—the Neolithic age,—to be followed after many generations by that of Bronze, and this again by that of Iron.

As has been said, this picture of early conditions applies particularly to western Europe; but it must be borne in mind that glacial ice did not cover every part of the globe, or any considerable portion of it, at any time,—in fact, did not cover every part of Europe,—nor was every part of the earth then inhabited. Population was naturally sparse, and many an extended region lay untrodden and unknown,—thousands, perhaps myriads, of years elapsing between the palæolithic period in western Europe and the beginnings of prehistory in those countries where the Stone Age still lingers in contact with the Metals, as in New Guinea and New Caledonia. As Hoernes remarks, "the dividing line between the historic and the prehistoric is not a straight line." Historic conditions had prevailed in the Old World for thousands of years before the New World was discovered, and New Zealand was still in its stone age when Tasman in 1642 made us acquainted with its existence; and when Captain Cook visited it in the second half of the eighteenth century it was still unchanged. Even at the present day the peasants of Spain use stone tines in their rudely constructed harrows.

MATERIAL

The Neolithic Period

THE material used for implements by prehistoric man in the Neolithic age was of the most varied kind. Dr. Ludwig Leiner enumerates sixty different minerals in use in thirty-six stations of the Lake Constance region alone, and scores of other kinds of stone found in other prehistoric settlements are not included in his list. It is evident from this that the prehistoric workman took the material he needed from that found ready at hand. It is not probable that he went wandering about, looking for some ideally perfect material; but having found from time to time what seemed to him to be of possible use, he gathered it in and laid it by until he needed it, if he did not need it at once, and its quality as determined by some simple comparative test would suggest its particular use, whether for cutting or hammering, boring or crushing.

Jade was, no doubt, one of the most prized materials. Like well-tempered steel, it possesses in finely adjusted proportions the qualities of toughness and hardness, which are essential in a high-class cutting implement; while its apparent scarceness, and the beauty and enduring qualities of the finished tool, would enormously enhance its value in the eyes of its owner.

But we are here dealing with prehistoric jade artefacts, not with nature's products, and it is time to hasten to a consideration of these and of the localities in which they have been found, and in doing this we shall confine ourselves to the examples furnished by the Collection.

NEOLITHIC JADE OBJECTS

THE jade relics of the Neolithic period found in this Collection may be divided into two classes:

I. Articles of every-day use, such as (*a*) implements and (*b*) weapons.

II. Objects to be worn on the person—(*a*) amulets, (*b*) ornaments, (*c*) souvenirs, (*d*) objects carried as insignia of rank or badges of office, or intended for ceremonial uses.

Implements

It has been customary to designate as *celts* all objects included in the first class, except, of course, needle-like tools, piercers, borers, arrow-points, and the like; but so many different forms are classed under this name

that some little differentiation is both necessary and possible. In France almost everything is called a "hatchet," and elsewhere there is a tendency on the part of some, in dealing with the Neolithic period, to call all cutting implements of stone "polished stone hatchets." A study of the specimens in the Collection shows that both terms are too general, for many implements, on the analogy of modern tools, may without impropriety be called axes, and many more show from their form and mounting that they were probably used as adzes. In the case of others, again, the chisel form is apparent, and this naturally leads to the knife.

Jade was never used for hammers, or, to be more exact, hammer-stones of jade have never been found, although the flakes of chert from which the modern Eskimos manufacture their arrow-heads are produced, according to Sir Edward Belcher,[1] who saw the process, by light taps with a hammer formed of a very stubborn kind of jade or nephrite. One of these jade hammers, which was exhibited by him, was oval in section, about three inches long and two inches broad, and was secured by a cord of sinew to a bone handle, against which it abutted; the ends were nearly flat. Prehistoric arrow-points of jade are also rare, yet a number were found in ancient caves at Mentone and shown at the Sixth International Congress of Prehistoric Archæology and Anthropology which was held at Brussels[2] in 1872; and one from China has been referred to in Part II. The chipped arrow-point of the commoner mineral flint was, no doubt, a more effective missile, and it had the further recommendation that it could be speedily and cheaply replaced. We are thus narrowed down among edged tools to axes, adzes, hatchets, chisels, scrapers, knives, gravers, harpoons, and the like, and among objects of general utility to knife-sharpeners, pestles, and picks. It must not be concluded from this classification, however, that any hard and fast line can be drawn between an axe and a hatchet, or that the implement which for convenience we call a hatchet or a chisel was never used as a knife, or that the axe or the adze could not be used as a pick. Even in modern times a penknife, originally designed for the making and sharpening of quill pens, may be put to a great variety of uses, and may serve a man, on occasion, both as a pen and a stiletto.

Axes

The axe-blades of the Collection represent six different localities, and are very varied in form and finish. The longest is from China, No. 292, a finely polished piece, 8.66 inches in length, with convex faces and curved cutting edge; the largest and roughest are from Alaska. These last vary in length from seven to eight inches, and betray only a minimum of effort and care in their manufacture. The largest, No. 242, is 8 inches in length, 2.875 in breadth, 1.875 in thickness, and has a weight of 2 pounds 11 ounces. The smallest measures 7 by 3.125 by 1.44 inches, and weighs about 1 pound 15 ounces. A better-made axe, No. 219, comes from Mexico. It is long, narrow, and thick, is as black as a chloromelanite, and has been smoothed by grinding. No. 228, from British Columbia, is narrow and thin, has a straight edge, and has been polished all over. But for the cutting edge, it might be classed as a chisel.

In No. 289, from New Caledonia, we have a different type of axe, shaped and finished in the manner of the "polished hatchets." It is about five inches in height, has a wide crescent-shaped cutting edge, convex faces, and thin sides which slope up symmetrically to a thin, narrow head, as shown in the colored illustration. A larger and heavier one, No. 284, from New Zealand, is somewhat similar in form, but is not so well proportioned. It has been polished all over, and shows a much higher state of culture on the part of the people who made and used it than any of the others in this class.

This is not to be wondered at, for though the inhabitants of this group of islands were still in their stone age and entirely ignorant of the metals when Captain Cook discovered them in 1769, they had advanced considerably in culture. For many centuries they had known and worked the jade found so abundantly in the West Island. They had attained a high degree of skill in fashioning it into implements, weapons, and ornaments. They practised agriculture, were skilled in weaving, and their methods of working flax were the envy of the white settlers of New South Wales at a little later date. Tribal government prevailed, and the sacredness of the marriage tie was carefully guarded by heavy penalties. They were

[1] Transactions of the Ethnological Society, N. S., I, 138.

[2] Comptes Rendus. Bruxelles, 1873.

cannibals, and indulged in human sacrifices; yet they possessed a high art-sense, as shown in the elegant carvings in wood with which they decorated their canoes, their weapons, and their utensils; and they practised tattooing with a graceful minuteness which was not devoid of symmetrical elegance. They never had a written language, and it may be said that they passed at one step from the barbarism of the Stone Age into the nineteenth-century civilization of Europe.

Adzes

The adzes of the Collection represent four different localities. The most typical pieces are mounted. No. 286, from New Zealand, and No. 247, from Alaska, mounted in a rough walrus-bone holder shaped to be set in a long handle, are well shown in the colored reproductions. The use of bone and ivory as mounts for stone implements is peculiar to the northwest coast of America. In the Swiss lake-dwellings horn was used, and wood in New Zealand, which was destitute of land animals. No. 244 is a typical Alaskan adze, the blade of which is set in a rough bone holder, socketed in which is a long handle of walrus-bone secured with stout thongs of rawhide which pass through two holes in the head and another, much larger, hole in the handle itself.

Number 280 is from the Bering Sea coast of Siberia; it is quite small and unmounted, and but for the curvature of the back might be classed as a chisel.

Number 254, from Kotzebue Sound, Alaska, while itself fit for an adze, appears to be only an outer longitudinal section of a larger implement. It is seven inches in length, and shows very markedly the sawing process by which it was separated from the rest of the piece. The practice of dividing an implement, that may perhaps have seen its best days, into smaller sections for some other purpose was quite common. A good example is seen in No. 288, two of the three (or four) longitudinal sections into which a flat hatchet had been cut by the aborigines of New Zealand in order to provide material for as many pendants or long ear-drops, which were so much prized by them. In the Peabody Museum in Cambridge, Massachusetts, are several specimens of jade celts which have been cut into two or more pieces in order to provide the "tongue-pieces" which the ancient Mexicans were wont to place in the mouth of a noble person after death, saying that it was "his heart."

Hatchets

The implements classed as hatchets are comparatively numerous, and represent ten different localities. The form is very varied. Two chisel-shaped hatchets are shown in the colored plates: No. 179, a Swiss specimen from Lake Neuchâtel; and No. 281, from Eastern Siberia, or perhaps the opposite coast of Alaska. No. 293, a flat four-cornered hatchet from China, has a straight cutting edge, and flat sides which slope upward to a narrower straight head. Few prehistoric implements are found in China, owing to the fact that the Chinese had passed their stone age, and were a civilized people, using the metals, and possessing among other mechanical contrivances the turning-lathe and the potter's wheel, when they arrived in China after a long eastward trek from Central Asia, at a period which cannot now be determined with any degree of accuracy. Whether they were acquainted with jade in their ancestral home in Babylonia (or wherever it was), we do not know. Their route probably lay, however, through Turkistan, the home of jade, where they may have lingered long enough to have become acquainted with the mineral and learned to appreciate its beauty and its enduring qualities, and the ancient hatchets we now find in China itself may have had their origin there. At all events, such jade objects as they possessed were much prized by them, and turned to good account as badges of office or insignia of rank. This specimen, No. 293, has been perforated, probably for suspension. *Yü*, the Chinese term which includes the jade minerals, occurs in their oldest books; and in the "Shu Ching" certain localities—all in the west—are mentioned as those from which the jade tribute should come. In the "Ku yü t'ou k'ao," a Chinese work dealing with jade antiquities, several objects not unlike this piece are figured and described as *Chên kuei*, or "tablets of rule." The perforated axe from China, No. 292, is also probably of the same class. It is about nine inches in length,

and narrow, with slightly curved faces, a crescent-shaped cutting edge, and rounded sides which slope up very gradually to a narrow head, and corresponds fairly well with the badges, designated *Yüan kuei*, illustrated in the work already mentioned and described in the "Chou Li," or "Book of Rites" (eleventh century B.C.), as "nine-tenths of a foot in length, carried by a silken cord, and sent by the Emperor to feudatory princes as a reward of virtue," the curving contour (implied in the name *Yüan*) being expressive of imperial good-will. The prehistoric hatchets found in China, as described in Part II, are there known as *yao chan*, "medicine-spades," from the belief that they were left by divine herbalists of ancient times who had used them to dig up medicinal roots and herbs.

Typical specimens of the flat hatchets in the Collection are shown in the colored illustrations. They are all small, have flat sides, a top or butt narrower than the cutting edge, and faces that are almost if not entirely flat. Nos. 177 and 182, the shapeliest and most perfect of these, are relics from some pile-dwelling settlement of Lake Neuchâtel. Nos. 180 and 183, from the same locality, are broader and rougher; while No. 198, from Lake Constance, is seen to be much altered exteriorly. Nos. 232 and 233, not here illustrated, are from British Columbia, and are allied to Nos. 180 and 183 in size and shape. The divided hatchet, No. 288, from New Zealand, already referred to, is an excellent example of this class of flat hatchets.

Numbers 172, 174, and 176, small hatchets from Lake Neuchâtel, and Cast F, a "hollow" hatchet from Posen, Prussia, form a sort of transition from the flat-sided specimens to the class with rounded or sharp sides now to be noticed. They are all small, have convex faces, rounded sides, wide, slightly curving edges, and narrow, pointed tops. Good examples are Cast R, a New Guinea implement in the Dresden Museum, and No. 181, from Lake Neuchâtel. No. 207, from Brittany, France, is longer, more graceful in outline, and better finished; while No. 222, from Guatemala, is the smallest. It is only 4.4 centimetres in length, and the cutting edge has a breadth of only 1.2 centimetres. The remaining specimens of the group are thicker and more dumpy, and have more decided crescent-shaped cutting edges. They represent Carinthia, Austria (Cast N), Lake Constance, the Swiss lake-dwellings (No. 169), and France (No. 212). A more perfect example in shape and finish is No. 287, from New Zealand; while the best is No. 226, a finely finished hatchet of compressed ovoid form, from Jamaica in the West Indies. It is perfectly symmetrical, has convex faces, a crescent-shaped cutting edge, and thin sides which curve gracefully to a pointed head. It will be seen from these descriptions and from the illustrations to which the reader has been referred, that endless variations in shape and size occur, attributable, no doubt, to the nature of the material and the shape and size of the fragment or the pebble from which the implement was made. Beginning with the thick rectangular specimens with straight edges, we pass to the thin four-cornered specimen, No. 293, and thence through a variety of specimens with thick bodies, thick straight sides, and straight cutting edges, to specimens with rounded sides, convex faces, narrow heads, and curving cutting edges, and from them in turn to those with thin sides, crescent-shaped cutting edges, and narrow heads, and thence to the perfectly formed and finished flattened ovoid specimen from Jamaica.

Chisels

The chisels in the Collection, which are not numerous, represent seven different localities: Switzerland, France, Guatemala, Mexico, British Columbia, Alaska, and Eastern Siberia. Typical specimens are illustrated in the colored plates, viz.: Nos. 186 and 188, from Lake Neuchâtel; and No. 234, from British Columbia. They are all small, are comparatively thick, have keen cutting edges, and could without impropriety be classed as knives.

Knives

The specimens that have been classed as knives show as great a variety of size and form as do the axes and hatchets. One variety partakes of the chisel form, being long and narrow, but sharpened from both faces, as in No. 275, from Kotzebue Sound, Alaska. In some cases they are short and dumpy, with flat faces and

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No. 182
HATCHET
Nephrite
Lake Neuchâtel

No. 177
HATCHET
Jadeite
Lake Neuchâtel

No. 178
HATCHET
Jadeite
Lake Neuchâtel

No. 191
KNIFE
Nephrite
Lake Neuchâtel

No. 172
HATCHET IN HOLDER
Jadeite-Nephrite
Lake Neuchâtel

No. 188
CHISEL
Jadeite
Lake Neuchâtel

No. 205
KNIFE
Nephrite
Lake Constance

No. 195
KNIFE
Nephrite
Lake Neuchâtel

No. 176
HATCHET
Jadeite
Lake Neuchâtel

PREHISTORIC IMPLEMENTS FROM LAKE-DWELLINGS OF SWITZERLAND

straight sides, and have all the appearance of chisels that had been worn down by frequent grinding, as in No. 204, from Lake Constance. Most of them show that one side of the cutting edge has been worn away more than the other, as in No. 195, from Lake Neuchâtel; No. 283, from the shores of Bering Sea; and No. 205, from Bodmann, Lake Constance. Another good example is No. 264, an Alaskan implement for use in carving bone and the like. Several have the appearance of unsymmetrical hatchets with one side shorter than the other, due apparently to the cutting edge having been worn away at one side more than the other, but really due to the original unsymmetrical form of the fragment or pebble from which the tool was fashioned. Good examples of this form will be found in No. 191, from Lake Neuchâtel; No. 211, a short thick knife from Alzonne, France; No. 206, a knife five inches long, from France; and No. 236, from British Columbia. In some of these the cutting edge is straight, as in No. 206 just mentioned, and No. 238, a small knife from British Columbia, which presents the appearance of a hatchet that had been ground by frequent sharpenings to a mere stump, and then used as a knife. Another example of this is to be found in No. 239, from British Columbia. Some knives are wedge-shaped, as in No. 225, from Guatemala, and No. 237, from British Columbia. One, No. 211, from Alzonne, France, still retains the form of the water-worn pebble from which it was made; No. 265, from Cape Prince of Wales, Alaska, is simply a small angular splinter with a sharp edge at one end. It is less than one inch in length, and seems to have been used for engraving and carving bone and ivory. Other very tiny knives are, Nos. 171 and 190, from Switzerland. No. 171 is a very neat little instrument—it can hardly be called an implement—about half an inch in length, and is prettily mounted in a perforated, slightly ornamented deer-horn handle. It was probably used as a lancet. Another very tiny cutting instrument, No. 261, a sharpened splinter from Sitka Harbor, Alaska, was also probably used as a lancet. One end has been entirely rounded off and polished, forming a little handle, which may also have been socketed in a horn handle.

Several knives of larger size have been mounted in deer-horn handles. They are all from the Swiss lake-dwellings. No. 196, from Lake Bienne, has a blade nearly three inches long. The handle has been hollowed out and smoothed at the top to receive another knife or similar tool, or to enter into a hatchet or handle. The blade of No. 197, also from Lake Bienne, is smaller, and is set in the end of a deer's horn ground down smooth at the tip. Another, with blade of medium size, No. 189, is similarly mounted and ground down near the tip. The cutting edges on all these are very keen, and No. 189 is so sharp that several thicknesses of paper can readily be cut with it with very little effort on the part of the user.

Another kind of knife is that called in Alaska *U-lú-ra*, or "woman's knife," because used for domestic purposes, such as cutting up fish or cutting out skin garments, etc. Examples of this are Nos. 263 and 266. The latter is a long, thin-bladed implement set in a wooden holder and provided with a curved cutting edge somewhat after the manner of the leather-cutter's knife known as a "half-moon knife." No. 263 consists of half a segment of a circle set in a walrus-bone handle in the manner of a butcher's cleaver, the curved edge being that used for cutting. No. 268 somewhat resembles this, except that it is not set in a holder or handle. In this connection it may be proper to mention the Chinese cleaver-like cutting implement, No. 294, very beautifully represented in the colored plate. It measures eight inches by four, and in the thickest part is only one-eighth of an inch in thickness. The cutting edge, now much notched, is very keen. It is possible that this specimen, like some already mentioned, may have been used in ancient times as a badge of office or rank. In the illustrated work on Chinese jade antiquities, the "Ku yü t'ou k'ao" already referred to, is figured a *Chên kuei*, or "tablet of rule," which corresponds very closely in size and shape with this "cleaver." This may have been a mere secondary use, but the specimen is none the less interesting.

Scrapers

We have seen that the implement known as a *scraper* early came into use in the palæolithic period, and assumed the form which it still retains among the Eskimos, who use it for scraping skins and other purposes. It was then made of flint, and still is made of that material by the Eskimos. It is described by Sir John Evans as "a broad flake, the point of which has been chipped to a semicircular edge, bevelled around the margin of the inner face similar in character to that of 'a round-nosed turning-chisel.'"

The Collection includes three scrapers, Nos. 273, 274, and 275, the blades of which are of nephrite. They are all from Alaska, and differ from the flint specimens found elsewhere in having straight edges bevelled on the inner margin like the blade of an adze or a plane.

They are all mounted in holders or handles of reindeer-horn or walrus-bone, shaped to fit the right hand, and in such a way as to ensure a good grip. In the case of No. 275, from Cape Prince of Wales, the grip is further strengthened by finely grooved indentations on the top and sides of the holder to fit the fingers and thumb. The handles of Nos. 273 and 274, which are comparatively modern, are decorated with incised hunting and fishing scenes. The use to which they were put was the dehairing, scraping, and softening of skins, and they can therefore be styled either *scrapers* or *skin-dressers.*

Knife-sharpeners

The knife-sharpener of jade seems peculiar to Alaska. Its general shape is that of a flattened rod, highly polished, tapering to a finger-like point at one end, and perforated at the other for suspension from the belt. These sharpeners seem to have been used as hones to give the finishing touches to an already sharp edge. No. 271 of the Collection, 5 inches in length, 0.94 of an inch in breadth, and 0.31 of an inch in maximum thickness, was carried by the wife of the chief of the Selawik tribe of Eskimos, and was greatly prized as an heirloom.

Pestles and Picks

Only two more implements remain to be noticed: No. 278, a pestle, and No. 276, a pick or root-digger, both from Alaska. The former is nearly five inches in length, and is merely the remnant of a boulder from which many other pieces had been cut. It is pointed at one end, but wide, of triangular cross-section, and convex at the other, where it is 1.5 inches in diameter. It gives evidence of having been in use for a long time, and is interesting from the fact that the lower or pounding end of the piece is impregnated with particles of fine gold, showing that it had been used for grinding natural gold-dust or sand containing gold-dust.

The pick or root-digger, No. 276, has the form of a thin bar of nephrite 6.83 inches long, 1 inch broad, and 0.56 inch thick, with rounded sides which taper toward each end. When in use it was provided with a handle of bone or wood in the manner of a modern pick. It differs in several particulars from the *Katu,* or "fighting-pick," No. 295, to be referred to later.

Dimensions

In looking back over the specimens examined, one cannot help remarking the generally small size of the objects which we have been speaking of as "implements." This is especially true of the adzes and hatchets from the lake-dwellings of Europe, British Columbia, Alaska, and the eastern coast of Siberia. The axes are of fair size: the longest, measuring nearly 9 inches, comes from China; next come the rough axes of British Columbia and Alaska, with an average of 6.73 inches, the largest being 8 inches; New Zealand and New Caledonia follow, with an average of 6.62 inches, and Mexico, with an adze measuring 6.75 inches. But in the case of the hatchets and adzes the smallness of the size is very marked. Omitting the Chinese specimens, the average of the hatchets is only 2.7 inches. In the Lake Constance region it is a little higher—3.26 inches; in France it is 2.86 inches; while in Mexico and Central America it is only 1.96 inches, including the beautifully formed piece, No. 226, from Jamaica, which is exactly 3 inches. In New Zealand it is 3.31; in British Columbia, 2.54; and in Alaska, 2.19. In the case of the adzes the result is practically the same. Omitting a 7-inch adze from Alaska and one of 4.31 inches from New Zealand, the adzes from British Columbia, Alaska, and the Bering Sea coast of Siberia show an average length of only 2.56 inches. Accustomed as we are to the finest tools of steel, it would be hard to believe that objects so small could have been used by prehistoric man as effective implements did we not know that in the present day many aboriginal peoples have no better tools, and that with them, generally with the assistance of fire, great trees are

cut down and hollowed out into canoes, or turned to other uses. The piles in the Swiss lake-dwellings show marks of the stone hatchets with which they were prepared for use, and Lubbock tells us that in the Danish peat-bogs several trees have been found bearing marks of stone implements and of fire, and in one or two cases stone celts were found lying beside them.

THE CASTS

Several much larger hatchets of fine outline and finish, which evidently belong to a very advanced stage of the neolithic period, are represented in the Collection by casts and illustrated in color. They are for the most part long and comparatively flat (some of them quite flat), have thin edges, slightly convex faces, and narrow top, and are finely polished throughout. The longest one, D, has a length of 14.94 inches, a breadth of 3.44 inches, and a thickness of 0.75 of an inch. It is flat and narrow, and has thin sides which taper up symmetrically to a pointed head. The original, which is in the Royal Museum at Cassel, Prussia, is said to have been found in Seeland, Denmark, but Dr. Meyer of Dresden is inclined to regard it as of German origin. It gives no evidence of ever having been used, and notwithstanding its size it may never have been used, as an implement, but for ceremonial purposes only.

The largest of these casts, P, is only one eighth of an inch shorter than the preceding, but is much wider and thicker. Its finding-place is unknown, but Dr. Meyer of Dresden, where the original is located, is convinced that it is of Mexican origin, as all celts coming from Mexico are of similar form. It is perfectly polished, and gives no evidence of having ever been used as an implement or a weapon. Dr. Meyer considers that "it may have been an ornamental or sacrificial celt," and he is not singular in considering these large, gracefully shaped hatchets as ceremonial and not utilitarian.

Another large hatchet of this class is E. It is 11.5 inches in length, has a wide, only slightly curved cutting edge, and blunt sides which taper to a round-pointed head. The original, which is now in the Collection of the Historical and Antiquarian Society at Münster, Westphalia, was found at Cloppenburg in Oldenburg, Germany.

A more perfect one is M. It is 10.06 inches in length, and is thinner and more graceful than E. The original, which is in the Ethnological Museum at Leipzig, was found at Münchpfiffen, near Allstedt, Saxe-Weimar. Cast G is 8.875 inches in length, has a somewhat wider cutting edge than the last, and has the further characteristic of being longitudinally bowed on one face and correspondingly concave on the other, giving the object a bent appearance. The original was found in 1830, near Erfurt, on the Bonifacius Mountain, near Harras, beyond Beichlingen, Merseburg, Prussia, and is now in the Historical and Antiquarian Collection at Erfurt. Another long, flat hatchet, H, found on Pfalzkyll Farm, near Trier, Germany, and now in the Provincial Museum there, is 10.94 inches in length. It is narrow and not quite symmetrical, and has a crescent-shaped cutting edge. Cast K represents another thin ceremonial hatchet of good form, which had been accidentally broken. Its length is 9.94 inches, the width of the cutting edge 3.06 inches, and the thickness at the thickest part only 0.56 of an inch. It was found near the Wehrden Chapel, Höxter, Westphalia, and is now in the Museum at Münster. In the colored illustrations is shown L, a less well-proportioned hatchet from Saxe-Weimar. Its length is only 9.06 inches, yet its cutting edge measures nearly 5 inches. It is as free from evidence of use as the others. The original is in the Ethnological Museum at Leipzig. Cast J has the same general appearance as the last, but is an inch shorter and correspondingly thinner. The original, which is in the Museum at Münster, Westphalia, was found at Borgholz, in the district of Warburg, on the left bank of the Weser. A less perfect form of hatchet is shown in I, from Saarburg, Trier, Germany. It measures 9.06 inches in length, is narrow and thick even at the sides, and is longitudinally curved as in the case of G already referred to. The two specimens which follow are comparatively crude when compared with those we have been considering. Cast C approaches I in dimensions, and has the same longitudinal curvature, but is flat on one face, bulging on the other, and has straight, blunt sides, sloping, as in the case of I, from a curved cutting edge to a narrow head. Its locality is given as

Seeland, Denmark, whence it was sent to Cassel, Prussia, by Landgrave Carl, a Hessian prince serving as field-marshal in the Danish army in the time of Struensee (1737–72). It is to be noted that the material of the hatchet is jadeite, and that in form it greatly resembles the stone hatchets of other material from the same locality.

Cast Q differs from all the others in being quite flat. The original is described by Meyer as "a long, flat, narrow, four-cornered hatchet with moderately curved sharp edge; the sides cut at right angles to the faces, and as broad as the hatchet is thick." The length is 14 inches, the breadth of the cutting edge is 4 inches, of the head 2.5 inches, and the thickness is 0.87 inch. The original is in the Leipzig Museum, and is considered by Dr. Obst, the curator, to be of New Zealand origin. Meyer, on the other hand, is strongly inclined to class it with the New Caledonian hatchets.

The last of the series of hatchets represented by casts is O, a long, thick, chisel-shaped jadeite hatchet with spreading cutting edge, narrow flattened faces, and rounded sides which slope up symmetrically to a narrow thick head. It has been finely smoothed all over, and is perforated near the head and apparently from one side. It is 8 inches in length, 2.32 in breadth at the cutting edge, 1.45 inches at top, and 1.45 inches in thickness. The original, which is in Dresden, was found on a mountain-side near Merida, Estremadura, Spain. Fischer was inclined to assume that it had been brought thither from Mexico, as no perforated hatchets had been found in Europe up to that time, and no jadeite implements had been found in Spain. Dr. Meyer points out, however, that Merida was a Roman colony, and states that other jadeite hatchets have since been found in Spain. M. Emil Cartailhac, writing in 1886 about his researches in Spain in 1880 and 1881, refers to this piece, and expresses the opinion that it is not of European origin.

Weapons

The next point which strikes a student of the Collection is the almost entire absence of what, to us with our twentieth-century notions of warfare, might be denominated weapons. We might from this circumstance be led to consider prehistoric man as a lover of peace, untroubled by encroachments and quarrels, having no need to defend himself from aggression, and no desire to make war upon his neighbor, did we not know that the period was one of conflict and bloodshed, and were we not mindful of the fact that we are dealing with only one of the materials used by prehistoric man: jade was scarce and valuable, as well as hard to fashion into weapons, hence other materials were used. We have seen that arrow-heads and spear-heads were fashioned out of flint and other tractable substances, and clubs of wood were no doubt common. Lubbock says that on *a priori* grounds alone it is probable that these little hatchets and other implements were used as weapons of war. The stone axe or tomahawk of the North American Indian, for example, served both as an implement and a weapon, and we are told that in a grave in Scotland was found the skeleton of a man of uncommon size, with one arm almost separated from the shoulder by the stroke of a greenstone axe, a fragment of which still remained in the bone.

Only three objects properly called weapons are found in the Collection, and they are all from localities in which the most advanced period of their stone age reaches down almost to our own day: No. 297, a battle-axe from New Caledonia; No. 296, a war-club from New Zealand; and No. 295, a "fighting-pick" or "killer" from British Columbia. In the first of these the blade is of rounded-rectangular form with a sharp cutting edge all around, measuring 9.06 inches in one direction and 6.19 in the other. It is perforated near one of the longer sides with two holes through which are passed the cords which secure it to the cleft jaws of the long, elaborately made handle in which it is set, and to the handle itself. It is a very formidable-looking weapon. No. 296, the *meré*, or war-club, of the Maoris of New Zealand, is a beautifully made weapon, and is always used unmounted. It is 17.81 inches in length, and in outline resembles a greatly compressed-elongated "Indian club," rounded at the lower end, and with slightly convex faces and thin, sharp edges. The slightly bulging head is pierced with a hole through which was passed the leathern thong by which the weapon was fastened to the wrist of the warrior when in use. This weapon, it seems, was not used for a downward blow. Most of the fighting seems to have been done with a long staff, and we are told that it was only when the combatants had come to close quarters, and the enemy was pretty well vanquished, that the *meré* was

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A

ROLLED PEBBLE

Nephrite

River Sann, Styria

N

SMALL THICK HATCHET

Jadeite

Dellach, Carinthia

Austria

B

ROLLED PEBBLE

Nephrite

Gratz, Styria

O

CHISEL-SHAPED HATCHET

Jadeite

Merida, Estremadura

Spain

C

FLAT HATCHET

Jadeite

Seeland, Denmark

CASTS OF PREHISTORIC OBJECTS IN EUROPEAN MUSEUMS

Forbes, Boston.

G

FLAT HATCHET

Jadeite

Bonifacius Mountain

Merseburg, Prussia

L

FLAT HATCHET

Jadeite

Münchpfiffen, Saxe-Weimar

Germany

D

LONG FLAT HATCHET

Jadeite

Seeland, Denmark

K

LONG FLAT HATCHET

Jadeite

Höxter, Westphalia

Germany

J

FLAT HATCHET

Jadeite

Warburg, Westphalia

Germany

CASTS OF PREHISTORIC IMPLEMENTS IN EUROPEAN MUSEUMS

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whipped out of the belt and a blow struck at the side of the head where the bones are weakest, and driven into the brain. This *meré* is one of the most beautifully finished specimens in the Collection. The third weapon, No. 295, is from British Columbia, where it is called *Nascah*, or "killer," by the Chimsian Indians. A similar implement was also in use in Alaska, where it was called *Katu*. It is a six-sided bar 10.94 inches in length, with a slight longitudinal curvature, coming to a sharp point at one end and to a four-sided angular point at the other. Its greatest thickness is 0.94 of an inch. When in use it was mounted about three inches from the top, where there is a groove, in a stout wooden handle some 18 to 24 inches in length. Weapons of this sort, we are told by Lieutenant Emmons, are very rare, and especially when made of jade. Their use never extended north of the T'linkit territory, or about sixty degrees north latitude. They seem to have been used chiefly on certain ceremonial occasions, as when a new building was being erected, or at the death and burial of a chief. In the former case the slaves who were to be sacrificed were brained with the *Nascah* and their bodies deposited in the post-holes, and in the latter the slaves were similarly brained and buried with the chief, so that when his spirit passed into the other world it would appear with a suitable number of attendants.

Ornaments, etc.

We now come to the second class of prehistoric objects in the Collection, viz.: those worn on the person as ornaments, amulets, or badges of rank or office. They are few in number, and all come from Mexico and Guatemala, except one important piece from New Zealand. They consist principally of beads and pendants of various kinds; some are sculptured, and all are polished. We have abundant evidence that the small objects of *chalchihuitl* which the natives wore on their wrists or around their necks, or in their ears or lips, were worn entirely as ornaments.

The objects consist of beads, both round and cylindrical; some were triangular, rectangular, hexagonal, or square in shape; others were fashioned as birds' heads or as fishes; some were used as labrets, and some as ear-ornaments. Specimens of several of these are included in the Collection. Among the beads is No. 304, which is five-lobed, measures eleven millimetres in one direction and seven millimetres in another, is of translucent, highly crystalline jadeite, and is beautifully polished. The cylindrical or tubular variety of bead is well exemplified in No. 306, illustrated in color. It is of rounded-square section, is seven centimetres long, and corresponds probably to the *kudatama* used by the Japanese along with the *magatama*, or "crooked bead" (No. 347), to form necklaces and amulets. As illustrating the rectangular ornaments, No. 301 may be mentioned. It is of Guatemalan origin, having been found on Mount Tacana at an altitude of 11,000 feet above the level of the sea, and bears on its face the combining form of the Mayan hieroglyph *kin*, meaning "sun." This consists of a small circle (a hole) in the centre, surrounded by a wider countersunk circle or hollow from which two short parallel lines proceed in each of four directions, perhaps to represent rays. Another form of ornamental pendant is that of a bird's head, No. 308, probably that of the falcon. It is well executed, finely polished, and perforated for suspension. It is finely illustrated in the colored plate. No. 303, also illustrated, has the form of a small mask carved in flat relief, with two submarginal perforations—one at each side in the line of the eyes—and one lower down, reaching from side to side, for suspension. No. 307, a curious trumpet-shaped ear-ornament, may next be noticed. It consists of a short tube, nineteen millimetres in diameter, for insertion in the ear, flaring at the other end like the mouth of a trumpet. Its greatest length is twenty-four millimetres. That these ornaments were actually inserted in the ear is undoubted. There is in the Peabody Museum at Harvard one that was found alongside the skull in which it had been inserted, and the monuments show many of the gods similarly ornamented. Another use to which jade seems to have been put in ancient Mexico is illustrated by No. 310, three human teeth inlaid with pea-green jadeite. They were found in a grave four feet deep near Guadalajara, state of Jalisco, Mexico, together with the skeleton and skull—both much decayed—to which they belonged. The custom of inlaying teeth does not seem to have been confined to Mexico. Similarly encrusted teeth, found in Yucatan, now form part of the Archæological Collection in the Peabody Museum at Harvard University, and a tooth inlaid with turquoise and labelled "Peru" is exhibited in the Museum für Volkerkunde in

Berlin. It is stated in the Reports of the Wilkes Antarctic Expedition that in some of the Pacific islands the natives are in the habit of ornamenting their front teeth with square pieces of rock-crystal. Human skulls have been found in Mexico magnificently encrusted with turquoise and marine shells—an after-death ornamentation. These teeth, however, were in all probability inlaid during the life of the individual, but whether for use or for ornament is not known.

The last, and probably the most interesting, of the ornamental or amuletic specimens from this locality to be mentioned is No. 309. It is a somewhat heart-shaped amulet, 8.7 centimetres in length, bearing on its face a finely sculptured human head framed in the gaping jaws of some animal, probably a serpent, whose eyes, nose, and teeth are clearly shown, while on its back is an inscription of nine (or ten) Mayan hieroglyphs which have hitherto defied complete decipherment and interpretation. The specimen is said to have been found in the state of Guerrero, Mexico; but archæologists who have examined it and are acquainted with Mexican antiquities are of the opinion that it is not Mexican but Mayan in motive and origin, and in all probability came from Yucatan, or perhaps Chiapas. The Tzentals of Chiapas were acquainted with both Mexican and Mayan civilization, and still use amulets of this kind. The face represented is thought to be that of a young woman, a goddess or a prophetess. The Tzentals, who used hieroglyphics similar to those found on the back of this piece, believed that the gods spake to them through young women, and all their insurrections were led by young women. One Mayan scholar directs attention to the fact that the eyes are closed, and he regards the figure as the representation of some deceased person, to perpetuate whose memory this ornamental amulet was prepared and worn. The object is undoubtedly of high antiquity, yet shows an advanced degree of culture on the part of the people who made and used such things.

The Mayas were the most civilized of all the American races. They occupied Yucatan and vicinity, and their settlements extended to the Pacific, including many tribes, such as the Cakchiquels, in Guatemala and parts of Chiapas and Honduras. "To them are due the vast structures of Copan, Palenque, and Uxmal, and they alone possessed a mode of writing which rested on distinctly phonetic bases." The height of their prosperity and influence was reached about a century before the Spanish conquerors invaded their soil, despoiled their cities, and lost for us the means by which we might have acquainted ourselves with the history of this interesting people.

It may here be remarked again that all these and other similar objects from this region were used simply as ornaments, or badges of nobility, and not because of any hidden medicinal potency in them, as Nicolas Monardes, the Spanish physician of Seville (1565), would have us believe. The testimony of Sahagun, Torquemada, and others who wrote in and of those ancient times is incontrovertible.

The Heitiki

The only remaining object belonging to this class is the New Zealand *heitiki*, or neck-ornament, No. 315. It is a large pendant, 15.5 centimetres in length, in the form of a grotesque squat human figure with big owl-like head and eyes, a conventionalized body, and highly attenuated limbs; and was worn suspended from the neck as a memento or souvenir of some dead ancestor, or of some one who had handled or worn it. Objects of this kind were handed down from generation to generation, and secretly buried in the earth when a family was about to become extinct. It is recorded by one of the early missionaries to New Zealand that when any one was slain in battle his friends would take his *heitiki* from his neck, lay it on a tuft of grass or on a green leaf, and weep and sing over it, using it to bring more vividly to their recollection the personality of the slain one. We are assured by competent scholars in New Zealand that the *heitiki* was not a representation of a god, and was never worshipped as such.

As we have already seen, the Maoris, when discovered by Tasman in 1642 and described by Captain Cook in 1769 and later, were savages and cannibals, indulging in human sacrifices; yet they had made considerable progress in the industrial arts, and displayed great artistic skill in wood-carving and jade-working. They had no acquaintance with the metals, and no written language, and were far behind the people of Mexico and Yucatan, whose state of culture and whose art more nearly approach the culture and the art of the ancient Chinese.

TOMB JADES

Before proceeding to the second division of our subject, and describing the ornate and artistic specimens of the lapidary's art, the product of civilized peoples in historic times, we find for our consideration, in China, a kind of transition period bridging over the interval between prehistoric and historic times. Prehistoric weapons and implements of the kind found in other parts of the world are not common in China, for the reasons which have been given above, where the three interesting examples in the Collection are referred to and described. These examples include a long, narrow axe of spinach-green nephrite perforated near the top, No. 292; a perforated hatchet of olive-green nephrite, No. 293; and a cleaver of peculiar form, of translucent sea-green nephrite with moss-green patches, No. 294. The last two are illustrated in color. The small celt, No. 324, which is illustrated in the same plate, has not, by the way, been included among the prehistoric implements because it is supposed to be an amulet fashioned in the form of a celt. But it may be really an archaic implement afterward adapted for use as an amulet, just as the small celt of somewhat similar form, No. 323, which is illustrated in water-colors, seems to be an ancient implement subsequently engraved with an inscription for ceremonial purposes. A number of these miniature jade celts were obtained by Dr. Anderson during his Expedition to Western Yunnan (see Report, l.c., 1871), and he was after a long discussion finally unable to decide whether they were prehistoric implements or only ceremonial celts intended to be worn as amulets for protection against wounds and other disasters.

For these and other reasons it has been found convenient to separate a certain number of pieces from the bulk of the Chinese collection and to group them under the head of *tomb jades* because they exhibit evidences of decomposition of material and staining of surface, such as would be produced by burial underground for a long period.

In addition to the Chinese pieces, there is one ancient specimen from Japan which has been classed among the tomb jades. It is a curved bead, or *magatama*, No. 347, of light emerald-green jadeite with dead-oak-leaf stainings, pierced for suspension as a pendant or as part of a necklace, where it is supposed to have been strung with a number of the tubular beads called *kudatama*, resembling the Chinese tassel-slide of nephrite, No. 321. No jade has hitherto been found *in situ* in any part of Japan, so that all beads dug up there are presumed to be of exotic origin.

No collection of Chinese jade could be considered complete if it did not include a certain proportion of these ancient specimens. The Chinese themselves, as a nation, cultivate the greatest reverence for antiquity, and they classify pieces of ancient jade as the rarest and most precious of their archaic treasures. So much stress has been laid upon this fact in the preceding articles that it is hardly necessary to discuss the subject further, although a short preface to the descriptions of the pieces included here may serve to indicate how they have come to be separated from the bulk of the Collection.

With regard to the term *tomb jades* with which this class is headed, T'ang Jung-tso has explained the derivation of the corresponding Chinese term *han yü*: how the word *han*, as written in his text, which originally signified "held in the mouth" and was applied to the jade which used in ancient times to be put into the mouth of a corpse before burial, has had its meaning gradually extended to include all kinds of jade found at the present day in ancient tombs. He adds that some good Chinese authorities comprise in this same term *tomb jades*, in addition to objects purposely buried with the dead, all kinds of jade things of ancient times discovered in the ground, however they may have become interred,—whether accidentally, engulfed by inundations or earthquakes, or intentionally, hidden during rebellions or famines and afterward forgotten. It is, in fact, difficult to separate the two classes, as all kinds of vessels and precious objects of jade used in former times to be buried with the dead among their other most valuable possessions.

The group of "tomb jades" in the Collection, comprising thirty-two pieces, contains examples of many of the curious insignia of rank, amulets, sacrificial utensils, etc., referred to in the Chinese books quoted in Part II, and ranges in time from prehistoric periods down to the dynasties of the Sung, Yuan, and early Ming. Most of the pieces are to be attributed to the Han dynasty, which flourished from B.C. 206 to A.D.

220. The Chinese empire at this time was extended far to the west, so as to include within its boundaries the province of Khotan as well as all the other principal sources of jade in Central Asia. Jade was then highly appreciated and widely used, as we have seen from the records of the period, and many pieces have survived to the present day; and this is one of the reasons why the ordinary Chinese dealer has been wrongly led to speak of *han yü* as "jade of the Han dynasty," in his ignorance of the original meaning of the rare word *han*, or "tomb," which has been explained above.

The Chinese are perfectly familiar with the disintegration of the surface and the gradual softening and decomposition of the material which occur in jade long buried in the ground. These changes are particularly well shown in the large gong, No. 327, which is inscribed with the date of the reign of an early emperor of the Han dynasty, and which has every appearance of belonging to that period. The surface is thoroughly

No. 328. LIBATION-CUP. HAN DYNASTY (B.C. 206–A.D. 220).

disintegrated, quite soft and opaque, and it might be mistaken for steatite or pagodite were it not for the fresh gap left by the removal of a section at the top for analysis, which exhibits the original structure of the jade. The libation-cup, No. 328, above illustrated, is another good example of the commencement of degranulation in the nephrite material under similar circumstances.

Jade in its crude state always contains a greater or less proportion of iron, and this, gradually becoming oxidized by process of time, causes staining of the surface, the color of the stain often extending inward, especially where there happens to be any flaw or vein in the material. All kinds of variegated "iron-rust" tints are produced in this way, passing from amber-yellow to the deepest brown, and sometimes becoming almost black. Such stains are well seen in the bell, No. 348; the large votive celt, No. 322, illustrated in color; the large sacrificial tablet, No. 318, of the full-page water-color illustration; the sacrificial libation-cup, No. 335; the tablet of rank, No. 317; and in several of the other ancient pieces. The heavy staining in all shades of *feuille-morte* browns, contrasting vividly with the original light grayish-yellow opaque surface of the jade, is effectively reproduced in the colored lithograph of No. 317. The water-color hand-painting of the sacrificial tablet, No. 318, exhibits again a faint greenish-gray nephrite stained and mottled over the greater part of its surface with dead-oak-leaf and black. The Chinese collectors delight in distinguishing all these shades, as well as those produced by any accidental contact of foreign bodies, such as copper, for example, in the most minute and fanciful way, fondly imagining blood-stains in the iron-rust and indigo-

M

LONG FLAT HATCHET

Jadeite

Münchpfiffen, Saxe-Weimar

Germany

I

LONG THICK HATCHET

Jadeite

Saarburg, Treves

Germany

E

LARGE FLAT HATCHET

Chloromelanite

Cloppenburg, Oldenburg

Germany

F

SMALL FLAT HATCHET

Chloromelanite

Zmyslona, Posen

Prussia

H

LONG FLAT HATCHET

Chloromelanite

Pfalzkyll Farm, near Treves

Germany

CASTS OF PREHISTORIC IMPLEMENTS IN EUROPEAN MUSEUMS

S

SMALL FIGURE

Jadeite

Probably Mexico

Q

LONG FLAT HATCHET

Nephrite

New Zealand (?)

P

LONG THICK HATCHET

Jadeite

Mexico (?)

R

SMALL THICK HATCHET

Jadeite

New Guinea

CASTS OF PREHISTORIC OBJECTS IN EUROPEAN MUSEUMS

233

spots in the oxidized copper; but their quaint conceits need not detain us here, as we can again refer the curious to the Chinese paper on the subject in Part II. The native antiquary, by long-continued friction of his fragment of tomb jade tied up in a "bran-bag," succeeds at last, perhaps, in bringing out as brilliant a display of color as the most ardent devotee of nicotine could desire to see upon his meerschaum pipe.

Similar stains of bright mottled-brown color are sometimes found naturally produced on the weathered surfaces of the pebbles of jade picked up in the river-beds, and are, perhaps, occasionally utilized to enhance the artistic effects of the carving of the finished work; but these must be carefully distinguished from the really ancient pieces. Ancient relics of tomb jade, on the other hand, are occasionally carved, after they have been found, into felicitous amulets, or ornamental appendages for the girdle, especially when the material happens to be effectively stained throughout. Sometimes a piece may be painted over with a brush to conceal a fracture or flaw, as in the large quadrangular seal of the Han dynasty, No. 333 (in the water-color illustration), which has been artificially colored red (faithfully reproduced in vermilion by the artist in his picture). This red may, of course, be easily scratched off the surface of the seal with a knife, and it could hardly be taken for a natural stain. The Chinese appear to have no knowledge of any artificial way of treating or staining real jade so as to imitate the disintegrating, mellowing effect of time.

There is, however, an abundance of "false jade" in China, and so-called "ancient jade" of this kind may be purchased at the small curio-stalls in the street of every town throughout the empire. It is generally in such cases carved out of steatite, or some such soft stone, and subsequently painted and stained to imitate the coloring of the real stone. Soapstone, being naturally soft, absorbs the colors readily, and the same quality makes it very easy to distinguish it from real jade by the point of a penknife.

One of the harder stones, the heavy compact variety of serpentine called *bowenite*, which is very closely allied to nephrite, although its specific gravity is less than 2.6 and its hardness only 5 instead of 6.5, is sometimes classed by the Chinese among the jades (*yü*). Its discoverer in America, Mr. Bowen, after whom it was named, classed it at first as a nephrite. An example of this mineral is seen in No. 325, a sacrificial tablet of yellowish-white translucent material with a very compact sinewy structure which is beautifully stained all over with warm shades of russet-brown. It would be a sin to banish this specimen from the series, as its mythological associations are especially interesting and there seems to be no reason to question its antiquity.

BURNT JADE

The subject of the gradual disintegration of buried jade by the slow tooth of time suggests a note on the alterations of its structure produced by sudden exposure to intense heat. There are four somewhat remarkable pieces of burnt jade in the Collection, which may be referred to as examples of the disintegrating effects of fire on the material. They must have come originally, in all probability, as salvage from the ruins of the Summer Palace at Yuan Ming Yuan, near Peking, after it had been burned during the Anglo-French expedition in 1860.

The first is a small incense-burner of nephrite, No. 394, with an open dome-shaped silver cover, the surface of which, originally white, has been changed by fire to an opaque, finely crackled calcined gray. It is so much altered as to lose all traces of its ever having been jade. The delicate carving, however, remains, and some of the polish is still left, although the whole piece is now more like porcelanite jasper. Black staining shading off to gray on the foot seems to be due to a copper stand on which it once stood, and some red streaks and splashes on the opposite side of the little urn to oxidized iron.

The second example, a quadrangular vase, No. 395, of white nephrite with pale-greenish tint, has been only partially calcined. The lower part, which was not seriously affected by the direct action of fire, is of a pale-greenish white with black stains, which may be due to infiltration in the cracks, or to the action of pyroligneous acids generated during the conflagration. The upper part seems to have suffered actual contact with the flames, and has been changed to a very faint brown opaque substance resembling calcined bone.

The third specimen is the vase, No. 435, which is boldly carved with a pair of five-clawed imperial dragons in pursuit of the "jewel of omnipotence," a design betraying its palace origin, apart from the merit and vigor of the carving. The nephrite material, originally white, has been changed by fire to an opaque ashy tint, and has been almost thoroughly calcined by the great heat so as to show no longer any life in the stone.

The fourth instance of burnt jade, the small flower-vase, No. 650, is perhaps the most seriously affected of all, the color, probably originally white, having been calcined to a mixture of ashy-gray, yellow, and brown. The great heat has affected not only the color, but also the substance of the vase itself, reducing the specific gravity to 2.64, and the hardness from 6.5, the normal hardness of nephrite, to 3 at the lower end and 5 at the upper end.

Some marks of fire are sometimes left on the blocks of crude jade loosened from the quarries by the aid of wood fires, as related in Part I, in the description of the processes of mining in Burma in the present day; but these are generally removed when the block is being sawn into shape and carved by the wheel on the lathe.

II. HISTORIC

After a brief sketch of the interval which connects the prehistoric period with the historic, we come to the final part of our subject, and are prepared to attempt the treatment of the extensive series of art objects of jade which is displayed in the Collection. The previous studies and investigations comprised in this volume have been mainly intended to lead up to an appreciation of the value of jade as a material for artistic work. The art objects will be described in detail in the Catalogue which forms our second volume, so that the limited space at our disposal here may be utilized for a general summary of the manifold resources of jade from an artistic point of view. This will most conveniently follow the order in which the art objects are arranged in the Catalogue, according to their place of manufacture, as set out in the following table:

1. China.
    - *a.* Carved Jades.
    - *b.* Jewelled Jades.
    - *c.* Jade Flowers and Fruit.
2. India.
    - *a.* Carved Jades.
    - *b.* Jewelled Jades.
3. Annam.
4. Europe and New Zealand.
    Nineteenth-century Jades.

1. CHINA

The Chinese have been from the earliest times the most enthusiastic admirers of jade. They esteem it as more precious than jewels, more valuable than gold or silver, and it is always classed by them as the first of precious stones. It ranks unquestionably with them as the most perfect material in creation, and as the most beautiful substance in which the thought of man can be embodied.

The reasons for this preference, which reaches back, as we have seen in Part II, to the dawn of Chinese history nearly five thousand years ago, are not so easy to define. To the European eye, as M. Paléologue says,[1] "It may even appear a little exaggerated: however pure jade may be, it possesses intrinsically neither the brilliancy of rock-crystal, nor the variegated tints of carnelian, nor the rich colors of sardonyx, nor the iridescent transparency of the onyx and oriental agate; the waxy aspect which is its peculiar quality only allows, on the contrary, to be given to it, by the most delicate and finished work, a vague translucency

[1] L'Art Chinois, 1887, p. 156.

which leaves it dull beside these quartz stones with their rich tones and varied play of color." This art criticism, it should be stated, applies specifically to nephrite; a glance at No. 355, etc., will show that it is not so applicable to jadeite, which has generally a much more brilliant tone of coloring than nephrite. So M. Jacquemart, the distinguished critic of lapidary art, whom we have already quoted in Part I as an enthusiastic admirer of the artistic merits of jadeite, describes it, under the name of *jade impérial*, as a peerless gem, almost rivalling an uncut emerald when green, and more effective than the richest of agates when variegated with mingled shades of green and white.

The ancient "Book of Rites" says of jade that it is, as it were, the subtle essence of the rainbow which has taken a concrete form and become incorporated in the stones of mountains and rivers. The hardness and toughness of jade were additional qualities which have made it always so highly valued by the Chinese for ritual and ceremonial objects. The most important vessels, in the earliest times of which we have any record, were made of jade, bronze being used in the fabrication of the rest. In later times the respect for ancient rites which distinguishes the Chinese has contributed to preserve for jade the character of being the most precious and imperishable of materials, with which it was endowed from the very first days of Chinese art.

How far these ideas were derived from an earlier use of jade for the fabrication of prehistoric weapons and implements we are not told. These are occasionally discovered in China, although when found they are generally referred by native antiquaries to a supernatural origin, and supposed to be missiles of the thunder-god or spades of a semi-divine Taoist herbalist. The forms of many of the ancient insignia of rank would really seem to have been modelled on similar lines, so that they might even be classified under the heading of ceremonial celts and regarded as "survivals."

Jade has besides, in the eyes of the Chinese, a symbolic value, in accordance with conceptions which we find it difficult to follow, but which form the base of nearly all their systems of philosophy. We have seen how Confucius, in the sixth century B.C., explained to one of his disciples how its high value depended on the way its chief qualities corresponded to the five constant virtues of humanity; and, again, how jade of different tints was chosen, on various occasions of sacrificial worship, after an elaborate color symbolism which reminds us of that of the ancient Babylonians. These points have been fully indicated in Part II by T'ang Jung-tso, who relates that the ancient Chinese would ransom fifteen walled cities with a single piece of jade, and that a modern mandarin would give a thousand ounces of silver for a pair of bracelets of emerald-green jadeite. It is only in pre-Columbian Mexico that anything like a parallel can be found, where, as Bernal Diaz tells us, Montezuma once said, as he added some jadeite stones to the presents given by him to Cortez for the King of Spain: "To this I will add a few *chalchihuis* of such enormous value that I would not consent to give them to any one save to such a powerful Emperor as yours. Each of these stones is worth two loads of gold."

No. 383. SMALL, SLENDER VASE. MING DYNASTY (1368–1644).

The importance of jade in the eyes of the Chinese may be shown from another point of view. In the historical period of their history, jade has on two occasions led to a change in the title of the reigning emperor. The first occasion is recorded in 164 B.C., the sixteenth year of the Emperor Wên Ti of the Han dynasty, when a jade cup engraved with the inscription, "Prosperity and Long Life to the Lord of Men," was presented to the emperor, who thereupon ordered a general feast, and decreed that the title of his reign should be changed to Hou-yuan, to commence with New Year's day of the following year (163 B.C.). The second occasion is re-

corded in the annals of the year 762 A. D., the seventh of the reign of Su Tsung of the T'ang dynasty, which was changed to Pao-ying—*i. e.*, "jewel-endowed"—in consequence of the presentation by the Governor of Ch'u-chou of twelve objects of jade and jewels to the state treasury. The official list is given in the annals as follows:

1. A celestial amulet in the form of a mandarin's audience tablet, eight inches long, three inches broad, rounded above, squared below, with a perforation near the round end, made of yellow jade.
2. A jade chicken carved with feathers and every detail in white jade.
3. A perforated medallion (*ku pi*) of white jade, between five and six inches in diameter, with millet grains in relief without visible marks of carving.
4. A pair of Hsi Wang Mu[1] bracelets made of white jade, six to seven inches across.
5. An emerald jewel of rounded shape, flashing with brilliant rays.
6. A pearl of great price, of the shape of a hen's egg, shining like the moon.
7. A balas ruby, as large as a big chestnut, of cherry-red color.
8. Two branches of coral, an inch and a quarter long.
9. A jade *chüeh*, in the form of a broken ring, like a bracelet with a fourth of the circlet wanting.
10. A jade seal, half as large as the palm of the hand, oblong in shape, cut in intaglio with a deer, so that a deer appears impressed when it is used.
11. A jade hook for the empress to gather mulberry leaves with, as fine as a bent sinew, mounted on a gold handle.
12. A stone axe of Lei Kung (god of thunder), four inches long, two inches broad, not perforated, in structure as fine-grained as green jade.

The official who presented these things pretended that they had been given to him by a Buddhist nun, who, sorrowing for the troublous times, had ascended to heaven and received them from the hand of the celestial deity; but their virtues proved to be of no effect in alleviating the troubles, and he was forthwith thrown into prison and soon after executed as a fraudulent deceiver who had tried to attribute a supernatural source to mundane things.

The T'ang dynasty was the Augustan age of Chinese art and literature, and the poets of the period are always singing of the pleasures of luxurious surroundings and of wine-bibbing in cultured company. Jade wine-cups are constantly referred to by them as the most valued of vessels; in Chinese poetry they take the place of the classical murrhine cups of the true Augustan period. But those interested may be referred to the "Poésies de l'Époque des Thang," translated by the Marquis d'Hervey Saint-Denis. Porcelain first came into vogue early in this dynasty, when the first supplies were sent to the capital, Si-an-fu, for the use of the court, from Ching-tê-chên, under the name of imitation jade (*chia yü*). The first pieces were of white body invested with a white glaze. The celadon glaze, which came in later, took its color inspiration from green jade, so that to jade must be given the credit of suggesting both of these early ceramic productions.

During the Northern Sung dynasty (960–1126 A. D.) several illustrated books on jade were published, and a large imperial collection of jade was brought together in the Hsüan-ho Palace at K'ai-fêng-fu, in the province of Honan, which was dispersed when the city was captured by the Juchen Tartars a few years later. It was in connection with this collection that we first read in contemporary records of the arrangement of a series of jade pebbles of every color as tests for comparison and classification of the art objects.

The artistic value of a given specimen may be said to depend on two criteria: 1. The intrinsic beauty of the material. 2. The merit and finish of the workmanship. We may turn now to the Collection to discuss it from these two points of view, beginning with a sketch of some of the characteristic colors of jadeite and of nephrite, and passing on to an outline of the technique revealed by the workmanship of some of the more important objects, referring, as much as possible, to the pieces illustrated in the present volume.

When the Collection was first displayed as a whole it was arranged on a color basis only, without reference to locality, date, form, technique, or material. The pieces formed a long series presenting an almost continuous gradation from white of many different tones, through gray, lavender, yellow, brown, and green of varied shades and mottlings, to black. But as more specimens were added, this method was found to be too cumbrous, and the Collection had to be rearranged and classified in further detail under the headings of country, style, period, and material. For the determination of the material, jadeite or nephrite, specific

[1] The fabled queen mother of the West.

No. 633

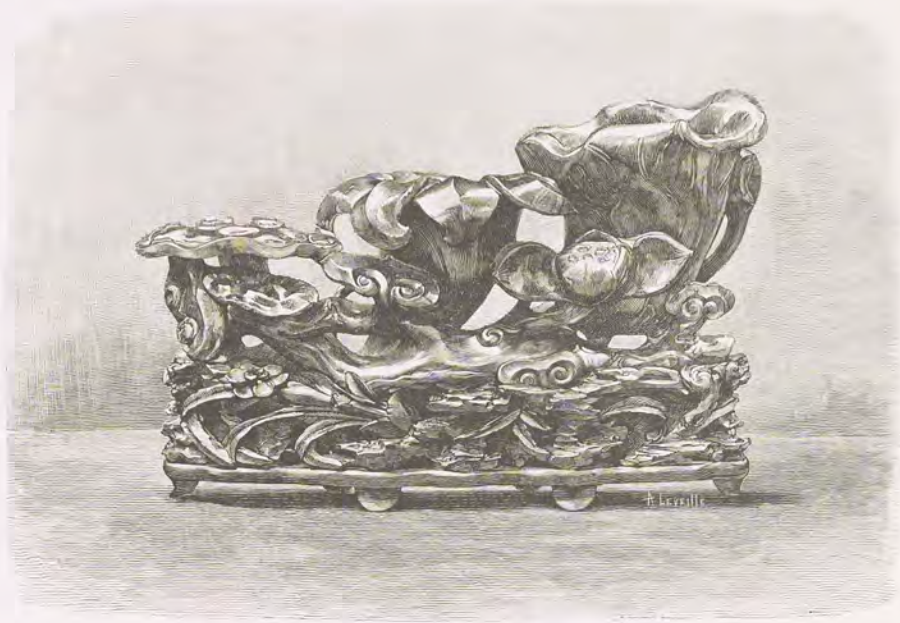
TRIPOD INCENSE-BURNER

(*Ting Lu*)

Ch'ien-lung (1736–95)

Nephrite

gravity was proved to be an important means of distinction, the mean density of some 100 jadeites, as given elsewhere, being found to be 3.32, and of 6 chloromelanites 3.40, while the mean density of nearly 500 nephrites was found to be 2.95. In addition to the specific gravity, the relative hardness of every piece was also tested, that of jadeite being 7, of nephrite 6.5; and if any doubt still remained, a section was taken off for microscopical and chemical examination. The results of all these tests will be seen recorded in the descriptions of the pieces in Volume II. It may be mentioned here that the specific gravity is not given in a very few cases only, where the specimen was mounted in such a way as to prevent its being taken. The dimensions and weight are also carefully recorded, except in the description of the pots with jade flowers and fruit, where the weight is not given because there is really so little jade upon the objects. Color still remains the ultimate basis of arrangement of the art objects after they have been classified in the way indicated above, the final order proceeding as far as possible from lighter to darker tints.



No. 410. LOTUS LEAF AND LILY. MING DYNASTY (1368–1644).

The origin of the various natural colors observed in jadeite and nephrite has been scientifically discussed by Professor F. W. Clarke in Part III. The same part gives abundant references to the rich scale of colors represented in the Collection, which is more fully indicated, in addition, in the Color Table in Volume II. It also includes notes on the colors due to the agencies affecting the jade after its formation, such as weathering and other causes leading to alteration of its natural colors, and absorption of foreign coloring materials, either natural or artificial, producing veins and staining of varied tint. The qualities of translucency, lustre, opalescence, and sheen which characterize some varieties of jade are also alluded to, as well as the inclusions of foreign minerals, such as chromite crystals, arsenopyrite, or mica scales, which are occasional causes of characteristic internal reflections. There is room here only for some further remarks on the principal colors appreciated in China, which may be best set forth as a short commentary upon T'ang Jung-tso's article in Part II.

The older Chinese writers, as he explains, refer in their books to jade of many different colors; but these colors may be generally grouped in five classes, and described as varied tints of white, green, yellow, red, and black. Combinations of these colors in the same materials used sometimes to be distinguished by special names; there was one, for example, applied to a piece half red, half white, and another to a joint combination of the three colors green, white, and red. Special names used also to be given to different varieties of the same color: the greenish-black jadeite now called by us chloromelanite was *yi;* ordinary black nephrite was *chioh;* while a peculiar black jade which could be polished to make mirrors was *chiu.* But we can never be quite sure that the older writers are always describing under the general term of *yü* the minerals which we now class as jade. Most of the quarries which were worked by the Chinese two and three thousand years ago have doubtless been long since exhausted, so that such points may never be settled. In the present day, at any rate, as the author observes, the green and white colors are very common in China, and black is occasionally met with, but the red and yellow hardly exist; so that even for sacrificial objects of red and yellow jade required for imperial worship it is impossible always to find genuine material.

White is the color specially esteemed in China, and collectors of jade are described as keeping a set of ten little tallies or tablets of sawn jade, arranged in a chromatic scale of tinted whites, for the comparison of any new specimen added to their collection. The first and rarest of the ten is said to be of a fine white translucid grain, resembling mutton fat, tinged with faint pink throughout, and is declared to be a jewel of inestimable value, a piece in ten thousand, hardly to be met with once in a lifetime. But scientific observers discredit the existence of pink jade. The charmingly artistic little cup, No. 366, illustrated in color, pellucidly pinkish-white with spots of golden russet, which was brought from Peking as a rare example of the class, has accordingly been dethroned by the mineralogist from its pride of place, and it is classed by Professor

Walden, after a careful chemical examination, among the quartz stones, so that it appears now under the novel heading of *jadeite quartzite*. It is a remarkable instance of the great difficulty of reconciling the art notions of the East and the West.

The existence of blue jade has also been seriously questioned. It is not in the list of colors immediately before us, but the Chinese require "cerulean jade" in their symbolic sacrifices to heaven, and it has been suggested that they might be satisfied with green for the purpose, which is often confused with blue by so many primitive nations. But jadeite is occasionally strongly tinged throughout with blue, as in the charming rustic vase, No. 362, which is illustrated by a colored etching, and which is described as remarkable for its intense blue color, contrasting so effectively with the weathered spots of golden-russet or brown-amber tint, which have been taken advantage of by the lapidary artist to tip the petals of his flowers. Another vase, No. 497, of light grayish-green color, is also described as mottled with shades of blue. Pale lavender is one of the most characteristic colors of Burmese jadeite, as shown in the small double-gourd vase, No. 487, which is illustrated by chromolithography. Specimens of similar color are reported to come from quarries in the Chinese province of Yunnan. The light-lavender ground is most highly prized as a material for artistic carving when flecked, as it often is, with emerald-green, or when marked with spots of russet-brown, as in the miniature figure of the god of longevity, No. 486. A jadeite of lavender color with a more decided tone of blue is said to come from Tibet; it is exemplified in the small statuette of the Venus de Milo, No. 799, which was specially carved for the Collection in Paris.

No. 458. LONGEVITY DIVINITY, SHOU LAO. CH'IEN-LUNG (1736-95).

Next we come to red jade. The old Chinese speak of a red jade of extremely rare occurrence, "red as a cock's comb," which they considered the most valuable kind of all. But we never find red as a natural color of the mineral, and have come to the conclusion that red cockscomb jade does not exist as a whole natural stone. The clue to the problem is suggested by T'ang Jung-tso, who tells us that some of the best white pebbles in the river-beds of Khotan are found invested with a red "skin." When this skin is of an attractive amber-brown hue resembling that of the rind of the russet pear, it is carefully preserved by the lapidary to form the outer layer of a snuff-bottle, archer's thumb-ring, or ornamental pendant, and carved by him in openwork in the manner of a cameo. An example of such work is seen in No. 710, a small belt-clasp with an upper layer, nearly a quarter of an inch thick, of clear brownish-red tint, which the artist has skilfully cut in the form of a couple of red dragons, resting upon the greenish-gray body of the clasp, so that the dragons serve as an open cameo decoration. The red skin, as the Chinese say, is gradually developed on the surface of the white jade by weathering after it has left its original bed. White jade, according to Professor Clarke, sometimes contains over four per centum of ferric oxide, enough to produce all shades of red and brown when rusted by the sun and wind. The colored illustration of the figure of Shou Lao, the deity of longevity, No. 651, shows some of these variegated coffee-brown and grayish-brown tints, contrasting vividly with the portions of the greenish-white body of the nephrite, which are left to form the face and hands of the statuette: the brown skin here is the most prominent feature of the piece. The little stork, No. 353, again, is carved out of a piece of bluish-white jadeite stratified with a similar layer of coral-red color. The red jade of the Chinese would, in fact, appear always to be merely a cutting or slice of such a colored incrustation. It

would not be difficult to find a crust of sufficient thickness to supply the *pi*, or perforated medallion, of red jade which is required by the emperor in his annual worship of the sun at the summer solstice. Bright reds of many different tones are looked for on tomb jades, developed while the pieces have lain buried underground in contact with other substances, as described in Part II, where carnation, vermilion, crimson, and purple are severally alluded to as stains, but not, of course, as natural colors of jade.

Yellow jade certainly does exist, in spite of M. Paléologue,[1] who asserts that authors who refer to varieties of yellow and orange jade are laboring under a misunderstanding and have wrongly applied the name of *jade* to sardonyx. Yellow jade is rare, but the Collection is unusually rich in actual specimens, which have all the characteristics of genuine nephrite. The most notable piece is the archaic libation-cup, No. 459, which is illustrated in water-colors; it is yellow with a very faint greenish tint, and the artist has unfortunately put too much green upon his palette. Another example of a color much appreciated by Chinese connoisseurs is the dish supported by two boys, No. 402, shown by chromolithography. The vase supported on the back of a grotesque monster, No. 399, is pale yellow of waxy aspect, very finely polished, and so perfectly resembling beeswax that it might be taken for an object moulded in that substance. The pieces Nos. 397, 398, 400, 401, are also made of rare yellow nephrite, varying only in tone; they all exhibit designs of a peculiar archaic character. We know nothing of modern work in yellow jade, and have no record of the original source of the mineral.

Black jade is sometimes called by the Chinese *mo-yü*, or "ink-jade," and is highly esteemed by them when intense in tone and capable of being polished to a brilliant mirror-like surface. It is generally a nephrite thickly charged with inclusions of chromic iron. If less thickly charged, it has the effect of a white magma speckled with black spots, as if ink had been flecked on with a brush; toning down to paler shades of gray when the chromic iron is less in proportion, until it becomes a white jade with only a faint tinge of gray. When the crude piece is half black, half white, with sharply defined lines of demarcation, the lapidary occasionally takes advantage of the uncommon combination in working out his designs, following up and emphasizing with his tools the outline of some object which he fancies has been originally imprinted in the material by the hand of nature. He may succeed in producing in this way a medallion symbol of the *yin* and *yang*, the elemental powers of darkness and light, which are the base of all Chinese philosophy, separated by the orthodox spiral curve which he defines and deepens on the lathe along the line of junction of black and white. The brush-pot, No. 349, which is illustrated in colors, shows a typical nephrite with intense clouds of black shading down to light-gray tints, so as to give a marbled effect to the combination: it is an old piece, referred to the Sung dynasty (960–1278 A. D.), showing in its interior curious marks of the drill-work of the period, and is plainly wrought and smoothly polished to bring out the rare coloring of the material.

Jadeite, deepening through darkest green to black, becomes chloromelanite; but this, though it is reported to have been found in South China, is not appreciated by the Chinese as a material for art work, being too dense and opaque to repay the labor of carving it.

We come now to green, which is really the prevailing color in all collections of worked jade. Not only is it the most frequent single color, but it modifies all the other colors by tinging the mass, or by flecking and splashing the ground with brilliantly contrasting tones of vivid green. The many shades of green which are found in jadeite and nephrite respectively have been set out in Part III, with references to characteristic pieces in the Collection. The greens of jadeite are, generally speaking, the brightest in tint, ranging as they do from lettuce-green and pea-green to grass-green, and culminating in emerald-green with almost the lustre and purity of the precious stone from which the name is derived. This last is the distinctive note of the precious jade called by Jacquemart *jade impérial*, which the Chinese call *fei-ts'ui* from its resemblance to the plumes of the kingfisher they encrust on jewelry, and which the pre-Columbian Mexicans called *quetzalitzli* after the gorgeous feathers of the *Trogon resplendens*, worn by their chieftains. Some of its shaded tones are represented in the beautifully variegated dish, No. 355, which is illustrated in colors. The quadrangular incense-burner, No. 428, is a magnificent example of emerald-green as a whole color in jadeite, and the dragon and phenix cups, Nos. 358 and 359, exhibit a fine play of lighter pellucid shades of the color

[1] L'Art Chinois, *l.c.*, p. 155.

spreading into snowy clouds tinged with pale amethyst. The quaint pillow of jadeite, No. 426, in the water-color illustration, is a combination of emerald-green of many shades, passing into pea-green mottled with paler spots and slightly clouded with dead-oak-leaf and lavender.

Jadeite is more crystalline in structure than nephrite, and some of its effects as an art material are dependent on this peculiar quality. It may be sugar-white, like saccharine marble, or have a clouded silvery translucence, as in the granular variety known as "camphor jade," of which No. 488 is a notable specimen; the crystals may be so abundant as to give a frosted aspect to the polished surface, as in the bowl, No. 496, which reminds one of a clouded crystalline piece of galvanized iron. The matrix of ordinary *fei-ts'ui*, which is white flecked with emerald-green, is generally granular, markedly so in the variety of jadeite called poetically "moss in melting snow," of which the large circular dish, No. 492, and the pair of bowls, Nos. 494 and 495, are striking examples.

With regard to nephrite, its colors are generally less diversified, although an infinite variety of different tones is represented by the several pieces in the Collection, of which a selection has been made for these pages. The qualities of the material will be appreciated better from an inspection of the carefully colored illustrations in the present volume than from the most labored description. In the illustration of No. 654, one of the most important pieces in the series, three of the typical colors happen to occur together, the tall grayish-white column being mounted upon a spinach-green pedestal and crowned by an olive-green top. That of No. 462 is a careful study of gray nephrite in a vase of which the bold design, perfect polish, and exquisite finish display the peculiar excellence of the material as a medium for artistic lapidary work. The coloring of No. 679, again, is almost worthy of the original, a magnificent brush-holder of translucent texture and brilliant dark-green tint, changing to light greenish-gray with dark brown and russet. The colored etching of No. 704, which is, perhaps, the most successful reproduction of the decorative qualities of spinach-green nephrite, may be compared with that of No. 689, which exhibits the same general tone of coloring as displayed on the largest piece in the Collection, a heavy massive bowl intended for goldfish, boldly carved outside with imperial dragons, and inscribed inside with an ode by the Emperor Ch'ien-lung, dated 1774, telling how—

The colossal block was brought as a tributary offering from
    Khotan,
To be fashioned by skilful hands into a *wêng*-shaped bowl.
It has been carved with clouds brought down from the vault of
    heaven,
And with dragons rising in their might from the depth of the
    abyss.


No. 584. VASE. CH'IEN-LUNG (1736–95).

After this short discussion of the value of jade as a material for art work, we have to consider the finished objects and say a word or two about their form and technique, some of the principal motives of their decoration, and the uses for which they have been fashioned. With regard to the technique, an outline of the preliminary preparation of the material and of the processes of work generally followed in China up to the final steps which give to the finished piece its perfect polish, has already been given and illustrated. Among the many notable examples of the consum-

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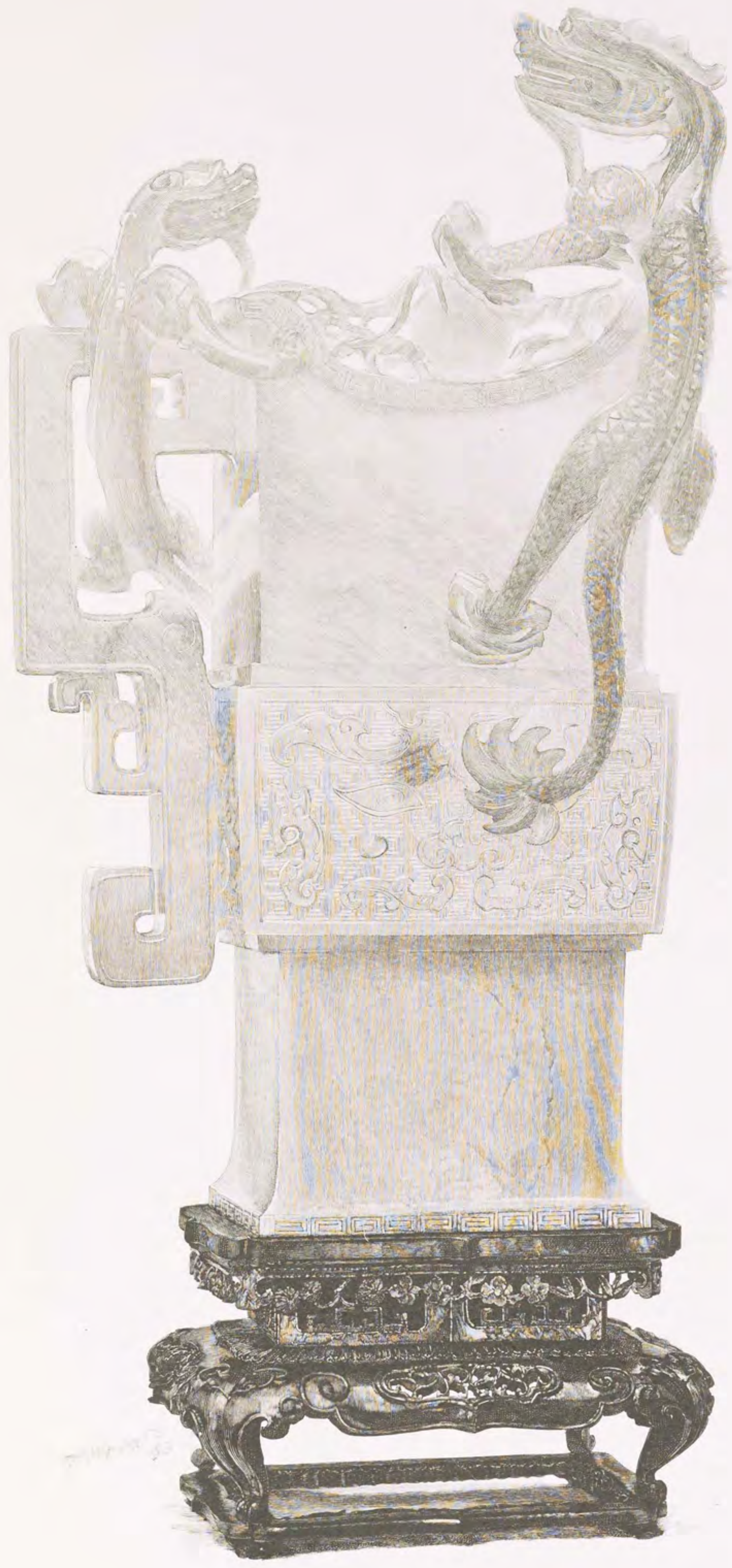
No. 369

SQUARE VASE

(*Hua Ku*)

Ming Dynasty (1368–1644)

Nephrite



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mate mastery of the artificer in this material, we may refer to the firm pose and graceful lines of the white vase, No. 439; to the bold, openly detached carving of the gray vase, No. 462, displaying, as it does, so fully its elegant form; to the elaboration and dignity of the religious scene rendered upon the Buddhist column, No. 654; and to the picturesque execution of the gathering of poets in the orchid pavilion of old Chinese story in No. 679, which designates it as the most fitting of receptacles for the brushes of an artist. The striking artistic qualities of some of the mounted screen-pictures, like No. 652, which are intended to be viewed as transparencies, should also be noted, as well as the minute finish of many of the smaller ornamental objects and personal ornaments which are etched in the next volume, such as the plaque, No. 628, which is a marvellous reticulation of dragons and floral scrolls reduced to the thinness of tissue-paper by the various processes of carving, undercutting, and hollowing, so as to acquire a wonderful translucency throughout. The round box with its cover, No. 645, of light sage-green nephrite, carved with pierced floral designs and symbols so as to resemble lacework, and the tazza-shaped covered bowl, No. 705, of spinach-green material, intricately carved in openwork with bands of floral scrolls, may finally be cited as examples of complicated fretwork executed by the diamond drill and wire saw of the Chinese lapidary, such as one would expect only from a worker in wood or ivory.

While the various points of technique involved in the fabrication of jade can be best attested by a minute examination of an individual piece, the infinite variety of form, in connection with the use of the object and the motive of its decoration, can be appreciated only by a general inspection of the Collection as a whole. This, ranging as it does over the whole field of Chinese art, often throws light upon contemporary work in carved wood, bronze, and pottery, although at the same time it requires some knowledge of these sister arts for its complete comprehension. There is no space for such discussion here, but many references to religions and mythology, history and folk-lore, manners and customs, will be found in Volume II, in the descriptions of the different pieces.

The Collection is remarkable for the number of pieces which have come, directly or indirectly, from the imperial palaces at Peking. These are often to be distinguished by the special character of their designs, in accordance, for example, with the strict sumptuary laws of the Chinese, which restrict the phenix and the five-clawed dragon to objects intended for the decoration of the palace or the personal use of the emperor. Among these last may be noted a magnificent dragon-handled seal, No. 464, inscribed with the name of one of the imperial summer palaces; a beautiful *ju-i* sceptre of white jade, No. 446, with an engraved inscription; and a jade-handled knife with a gilded steel blade, No. 736, the handle of which is incised with an inscription in the handwriting of the Emperor Ch'ien-lung, the date corresponding to 1744 A. D. The little ode, one of several in the Collection from the same imperial pen, may be quoted here as a sample of the rest:

This piece of bright pure jade brought from the Yü-lung[1] Valley,
Of palest sea-green tint revealed through its polished depth,
Has been carved with appropriate designs by a skilful craftsman
Into a handle of fitting form for a precious steel knife.
The "sliced fat"[2] stone has been adapted to slice fat!
Though the name originally expressed only its translucent whiteness,
It has become applicable to the use as well as to the material.
Is not this a curious coincidence between nature and art?
The sharp blade must not be carelessly grasped,
Nor must our imperial words be lightly turned to ridicule.

Written by the Emperor Ch'ien-lung in the first decade of the middle month of spring in the cyclical year *chia-wu*, and sealed with two imperial seals.

Verses by the same emperor (whose collected poems, by the way, fill many printed volumes) have been quoted in Part II from a screen-picture of the Buddhist saint Bôdhidharma, and from an imperial sketch of the pagoda-crowned Golden Island in the Yangtzĕ River, having been etched on the two sides of the circular plaque of ivy-green nephrite, No. 688. Some other rhyming stanzas of his composition will be found

[1] Yurangkásh, or "White Jade," River, in Chinese Turkistan.
[2] "Sliced fat" and "mutton fat" are well-known synonyms of white jade.

ennobling the massive fish-bowl, No. 689, of spinach-green jade, describing the two screen-pictures of white jade carved in relief, Nos. 580 and 638, or figuring as the sole ornament of a pale-green panel intended to be worn upon the girdle, as in No. 559.

The imperial dragon rising from sea waves into scrolled clouds, through which is whirling the flaming jewel of omnipotence, is well represented on the colored etchings of Nos. 604 and 689. In the colored lithograph of No. 606 it is posed as the dragon-king of Buddhist legend (Nagaraja) guarding the sacred jewel of the law, being inclosed with the eight Buddhist emblems in the same medallion. On the pair of jadeite cups, Nos. 358 and 359, it appears in a more antique form in conjunction with its frequent companion, the *fêng-huang*, or phenix. The dragon and the phenix are again found in combination upon the vase, No. 439. The phenix is figured alone on the jade frame of the mirror, No. 626, which is also said to have been brought from the Summer Palace in the year 1860. The archaic lizard-like dragon of ancient bronze with bifid tail, called *ch'ih-lung*, is faithfully represented in the lithograph of the gray vase, No. 462, which has been so often referred to, and in the water-color picture of No. 459, the largest and most important piece of yellow nephrite in the Collection. The curious fish-dragon vase, No. 460, so exquisitely carved in the shape of a pair of fish in the act of transformation into two winged dragons, is an illustration of the literary legend which relates that the sturgeon of the Yellow River becomes a dragon if only it surmounts the "Dragon's Gate" gorge—a type of the successful graduate who at last, maybe after many years of persevering effort, succeeds in getting his name enrolled upon the "Dragon List," the first step in the ladder of official promotion.

Two grotesque monsters of fabulous mien which figure as supporters of the twin-cylinder vases, Nos. 370 and 614, the latter of which is illustrated by a copper etching, are supposed to be intended to represent an eagle (*ying*) perched upon the head of a bear (*hsiung*), suggesting in a punning way the honorific title of *ying-hsiung*, or "champion." The "champion vase" was originally an arrow-receptacle of bronze given as a reward for military prowess. Another fabulous animal which calls for a word of notice is the Buddhist lion (*shih-tzŭ*), with flaming shoulders indicating original wings, which is usually sporting with a brocaded ball, as in Nos. 352 and 537, sometimes accompanied by smaller lions or cubs, as in No. 381, and often looking more like a dog than a real lion. Winged quadrupeds of grotesque shape, like those common in Assyrian art, are found in China as supporters of archaic vases, or as a decoration surrounded by scrolled waves, and are often classed together under the general name of sea-monsters. The twelve animals of the Chinese zodiac are all real animals, although they are carved here in light sage-green nephrite (No. 730) as a set of little half-human figures with animal heads and tails.

The elephant, horse, and ox are among the animals frequently represented in Chinese sculpture. The elephant is seen in the Collection, carrying vases filled with precious things in Nos. 444 and 739, and as the bearer of tribute from some foreign country in the decoration of the brush-pot, No. 683. The horse occurs plainly carved, as well as (among the jewelled jades) with ruby-mounted harness, emerging from the Yellow River, with the nine mystic diagrams of ancient Chinese philosophy on his back. The ox figures as a water-buffalo accompanied by a herd-boy with a bunch of millet in No. 438, a companion piece to the recumbent horse (No. 437); an ox carried Lao-tzŭ, the founder of Taoism, on his travels to the far west of China, as represented in No. 449; and another is often harnessed to a rough cart with a mat canopy in pictured scenes of these ancient times. The proper animal attributes of Shou Lao, the god of longevity, of whom Lao-tzŭ is supposed to have been an incarnation, are the deer, tortoise, and stork, as seen on the bowl of gray nephrite, No. 403, which is carved with a processional scene depicting the visit of Confucius to Lao-tzŭ in the sixth century before the Christian era.

There are, it is well known, three religions in China—Confucianism, Buddhism, and Taoism. The Chinese, however, eclectic rather than exclusive in their sympathies, may profess adherence to all three creeds without any sense of impropriety. A Chinaman, as his Excellency Herr von Brandt, an acute observer, remarks, is born a Taoist, lives a Confucianist, and dies a Buddhist.

Confucius himself was an agnostic, and his follower still devotes his chief attention to the ceremonial observances of the present world. As a scholar he prostrates himself daily before the ancestral tablet of Confucius, which is enshrined in every public school-room; and throughout life is duly observant of the sacrificial rites of ancestral worship, which date from pre-Confucian times. The cult is almost devoid of symbol-

ism. The wine-vessels and libation-cups of the ancestral temple, the covered dishes and platters for offerings of meat and corn, raw and cooked, of which so many are found in the Collection, are generally designed after the pattern of bronze sacrificial vessels of the three ancient dynasties, dug up from the ground, with the lineaments of the *t'ao-t'ieh* ogre projecting from a scrolled ground and encircled with rings and bands of rectangular fret.

Buddhism is of Hindu origin, and most of the Chinese Buddhist figures, symbols, and ritual designs have a marked Indian aspect. The mendicant's bowl, or pâtra, No. 622, is a notable example of this, its nine figures of Amitâbha Buddha being cut in Indian style, while the seal-mark, "Made in the reign of Ch'ien-lung (1736–95)," attests its Chinese workmanship. An image of Sâkyamuni, the historical Buddha, carved in mottled-gray nephrite, is seen in No. 461. There are many representations of Arhats, including immediate disciples of Buddha and later saints, in the Collection, whether as separate figures or subject motives of carved work. The cylindrical column, No. 654, illustrated by chromolithography, exhibits Buddha enthroned in a rocky paradise, with his chief disciples, the sixteen Indian Arhats, grouped in characteristic attitudes below. The first of these, Bhadravâja, appears as a separate figure in No. 610. Kanaka, the eighth of a series of "Eighteen Venerable Ones" carved in the reign of Ch'ien-lung for a Buddhist shrine in the "Reed and Orchid Pavilion" at Yuan Ming Yuan, is represented in No. 640, and labelled with a commemorative stanza written by the emperor himself. The screen-picture of the miraculous crossing of Bôdhidharma, the first Chinese patriarch, which is carved in high relief on No. 688 and engraved with a verse in the same august hand, has been already quoted and referred to in Part II. The eight felicitous signs (*pa chi-hsiang*), of Buddhist origin, which are found so often bound with fillets in architectural as well as in all other sculptured and painted decoration, occur everywhere in jade-carving; they comprise the flaming wheel, the canopy, the fish, the vase, the lotus flower, the umbrella, the knot, and the conch-shell. There is yet another Buddhist figure to be noticed, that of No. 440, a statuette in jade of the celebrated Chinese pilgrim Yuan-chuang (Hiuen-tsang), whose travels through the length and breadth of India from 629 to 645 A.D., translated into French by Stanislas Julien in the year 1885, have revealed to us so much of the ancient geography of the country.

No. 619. DRAGON WITH YOUNG. CH'IEN-LUNG (1736–95).

Taoism springs mainly from nature-worship, and many of its divinities are of stellar origin. The principal triad consists of the star-gods Fu, Lu, and Shou, "Happiness, Rank, and Longevity," which form the group of white-jade figures standing upon lapis-lazuli rocks under a spreading pomegranate tree in the water-color picture, No. 731. The star-god of happiness, Fu Hsing, stands here on the left, with his emblems, two flying bats; the star-god of rank, Lu Hsing, in the centre, holding a *ju-i* sceptre, with his emblems the tree-peony and red coral; the star-god of longevity, Shou Hsing, on the right, with a pilgrim's gourd tied on the head of his long staff, a sacred peach, the "fruit of life," in his left hand, and a magic fungus growing at his feet. This last divinity, known also as Shou Lao, the "Ancient of Ages," is found separately in the curious figure of mottled-brown nephrite, No. 486, illustrated by chromolithography, which has already been referred to; as carved out of light-lavender jadeite, in No. 531, and often represented in the Taoist scenes carved upon jade rocklets in the Collection. The Taoist triad, grouped under a spreading pine, is again the motive of decoration of the brush-pot, No. 609, a piece remarkable for the purity of its material and as a triumph of glyptic art in jade. No. 516, another artist's brush-holder, is carved with a mountain scene representing the Pa Hsien, the eight immortals of Taoist legend, coming to worship the god Shou Lao. These eight immortals take the place in popular estimation of guardian saints in some Roman Catholic countries, revered as being the patron saints of different crafts in China, etc. Their emblems are the *pa an hsien*, comprising the fan, sword, castanets, double gourd, basket of flowers, bamboo drum, flute, and lotus, which are carved in relief

upon the beautiful pair of emerald-sprinkled jadeite cups, Nos. 483 and 484, and again lightly etched upon the very transparent little cup, No. 489, which is also made of delicately shaded jadeite.

No. 616. TAOIST DIVINITY, WU LAO. CH'IEN-LUNG (1736-95).

The Taoist figure in the annexed illustration of No. 616 represents one of the Wu Lao, the "Five Old Ones" of ancient story, whose spirits animate the five planets and are occasionally personified as appearing on earth; he holds a Buddha's-hand citron in his right hand, in his left a cup of the draught of immortality for his faithful devotees. The Erh Lao, or "Two Old Ones," worshipping the god of longevity in a mountain paradise, on the brush-cylinder, No. 685, a notable example of "puddingstone" nephrite, are historical personages of the twelfth century B. C. who have been adopted into the faith and are masquerading as Taoist *rishi*, or hermits, giving a specious air of antiquity to the divinity of their adoration. The number of genii in the lower walks of Taoist mythology is almost infinite; many stories are related about the feats of the "two merry genii" who appear in bold openwork relief, with "wonderful cruse" and "magic salver," upon the slender hexagonal beaker, No. 447, a piece remarkable for its pure color and texture as well as for its clever glyptic work and perfect finish, to be worthily compared with that of its companion vase, No. 448, which is boldly decorated with a celestial dragon and a phenix bringing a spray of peony in its beak.

An elaborate seal-casket, No. 466, with a compartment for vermilion and pad as well as a receptacle for the great state seal, is a study of ancient symbols, displaying, as it does, the twelve emblematic figures anciently embroidered on robes as insignia of rank, in addition to the eight Buddhist emblems of good fortune, and the imperial dragon handle which marks it as a palace relic. Figure-scenes of historical and literary interest in the Collection are too numerous to describe here, but two may be alluded to as appropriate subjects for the decoration of the brush-pot of an artist or a calligraphist. The first is the "Orchid Pavilion" of No. 679 (colored lithograph), where poets used to meet in olden time to compose and recite verses, inspired by wine floated down to them in little cups by boy attendants, as they gathered in groups by the riverside. The second is the "Mountain Retreat" of Li Tai-po in the water-color picture of No. 623, where the famous poet of the eighth century was wont to write in the midst of beautiful scenery, while one of his boys was washing his palette in the rivulet below and another was preparing tea on the hillside, as commemorated in the well-known couplet:

> As the palette is washed the fish swallow the ink;
> The tea boils and the cranes are dodging the smoke.

Some of the most beautiful things carved in jade are, in fact, intended to furnish the writer's table or the artist's studio. Among them may be mentioned screen-pictures, vases for flowers or simply for ornament, receptacles for brushes to stand upright or to lie prone in, boxes and stands for India ink, hand-rests, paper-knives, foot-measures, paper-weights, water-pots of quaint design and dishes for washing brushes in, seals, and boxes for vermilion and pad; it is only the ink-stone which is not often made of jade, slates and other commoner stones being preferred for palettes.

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No. 337

LOTUS-LEAF VASE

(*Ho-yeh P'ing*)

About thirteenth century

Nephrite

GUERARD.

The Chinese artist is seen at his best in his delineations of birds and flowers, and the carver in jade and other hard stones is no exception to this general rule. The poet of the T'ang dynasty was a vivid impressionist, and delighted to surround himself with beautiful forms and objects, culled from the world of nature, suggestive of couplets for his impassioned verse. Jade was prized not only for the vague translucency of the material and the delicate work and finish of which it was susceptible, but also for the refined pleasure of handling a substance which was at the same time firm and unctuous, giving a sensation to the touch which has been compared to that which the patina of a beautiful bronze gives to the eye—a caress, as it were, to the tips of the fingers. Jade became in this way the most precious of substances, as the one giving the most refined sensations, suggesting the most graceful thoughts and the most delicate impressions. From this period may be dated the sensualism which has gradually pervaded Chinese art in all its branches, developing side by side with the hieratism of the old ritual.

The Collection shows everywhere how surprisingly the glyptic artist in hard stone has succeeded in rendering the soft flexibility of the lotus, the yielding pulp of a bursting magnolia, the graceful elegance of floral spray and foliage. The nymphæa lotus is perhaps the most favored flower of all, the type of purity in the vegetable world, as jade is in the mineral; for it grows unsullied out of the mud. The colored etching of No. 337 shows, in its vigorous archaic lines, how the leaf can be gathered into a vase and surrounded by the flower, fruit, and other details as a naturalistic decoration. Its gracious curves are indicated in the watercolor illustrations of Nos. 620 and 621, and carried out in the outlines of many other pieces which need not be separately referred to. The lotus is often accompanied by other water-plants, such as the sagittaria, with its arrow-like leaves, and the common reed; among water-birds found in connection with it are storks and egrets, wild geese and ducks, notably the brilliant mandarin duck; No. 463 represents a single duck swimming, with sprays of lotus and sagittaria in its beak.

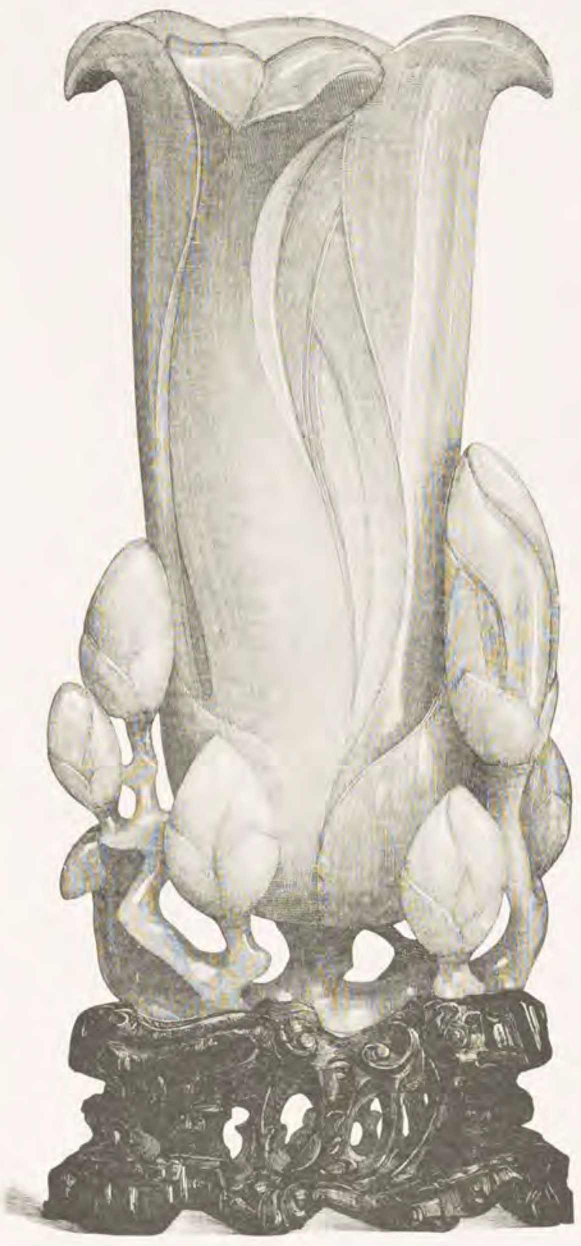
No. 589. FLOWER-VASE. CH'IEN-LUNG (1736-95).

A beautiful white vase fashioned in the shape of a magnolia blossom is shown in the illustration of No. 541. A second, herewith given, displays another flower-vase, No. 589, exquisitely modelled in the form of a Buddha's-hand citron. A third exhibits a paper-weight, No. 546, cleverly designed as a bitter gourd, the *Momordica Charantia* of botanists, with a praying-mantis crouching upon one of the lecythi. Among the gourds, a more ordinary motive is the double gourd, a variety of the bottle-gourd (*Lagenaria vulgaris*), as shown in the colored etching of the covered vase, No. 363, which is made of apple-green jadeite with splashes of rich pellucid brown. See, also, the brilliant emerald-green palette, No. 425, a veritable triumph of glyptic art work in this pleasing design.

The gourds are all ranked among the emblems of longevity, being very durable when dried. So is the branched fungus of many hues (*Polyporus lucidus*) which supports the little globular water-jar of white jade in No. 476, and is the original source of the form of the *ju-i* sceptres, as proved especially by the branched outline of No. 523. Among other types of long life are the plum blossom, bamboo, and pine, fragrant, green, and everlasting: these are found in combination in the fretwork decoration of the large spinach-green bowl and cover, No. 705; singly in the rustic plum-tree vase of blue-tinged jadeite, No. 362, and in the dainty little paper-weight, No. 575, a leafy section of bamboo carved in white nephrite. The dove, No. 417, is bringing a twig of prunus blossom from the land of the

immortals: a pendant to the two gigantic peaches, the fabled fruit of life, on which a pair of monkeys is frolicking, No. 376. The threefold fruit combination of peaches, pomegranates, and Buddha's-hand citrons, which is found on the jewelled brush-holder, No. 741, and on other pieces, figures the "three abundances" —*i. e.*, of years, sons, and happiness.

Among flowers not yet noticed are the chrysanthemum, outlined in the charming little cup-shaped vase, No. 456,—the motive also of the shape of so many of the fluted bowls and dishes in the Collection, like No. 670; the begonia, which has furnished two of the most charming of water-dishes for washing the brushes of an artist, Nos. 592 and 593; and the tree-peony (*Pæonia Moutan*), the floral emblem of rank and honor, the magnificent sprays of which are prime favorites with the jade-cutter, who often executes them in rich and complicated openwork relief. It seems almost bathos to pass from the glorious tree-peony to the humble cabbage, but it is necessary just to allude to the form of the flower-vase, No. 364, which is carved in lettuce-green jadeite mottled with emerald and gray; T'ang Jung-tso tells us in Part II, moreover, that in China melons and cabbages of precious *fei-ts'ui* are deemed a fitting decoration for an emperor's palace.



No. 541. MAGNOLIA VASE. CH'IEN-LUNG (1736–95).

The Chinese language, being monosyllabic and with a limited vocabulary to express its multitude of written symbols, is peculiarly susceptible of pun, or *double entendre*, and of being read in the way of a rebus. Some pieces of jade are often artfully designed to convey secondary meanings after the same fashion, like the marriage wine-cup of white jade, No. 600, and the cleverly executed bridal cup, No. 367, which are two of the pearls of the Collection, and, like so many of the hanging musical stones carved in the form of fish, connote ideas of good fortune and prosperity. So also with the designs of several of the medallions and pendants; but the consideration of such quaint conceits, which require some knowledge of Chinese to trace out properly, may be deferred to the descriptive part of the next volume.

Jade is highly appreciated for the *San Shê*, the well-known "set of three" vessels used for burning incense, which occurs so often in the Collection, artistically wrought in emerald-tinted jadeite, as well as in nephrite of varied color. The set in question comprises a box with a cover for the prepared incense or sandalwood chips, an urn with three or four feet to burn it in, and a vase to hold the miniature shovel and pair of rods for handling the fuel. This is the ordinary altar-set used for sacrifice before the domestic shrine, and it is also available for fumigating the air of the apartment and is often employed for that purpose as well. The larger temple sacrificial set of five pieces, called *Wu Kung*, composed of a central urn, two pricket candlesticks, and a pair of tall vases for flowers, is much larger in size and is not made in jade. When the Emperor of China sends presents to a foreign potentate, a *ju-i* sceptre and an incense-burning set of three vessels carved in white jade are usually included in the list. The same things, worked either in bronze, cloisonné enamel, porcelain, carved red lacquer, or hard stone, are to be seen placed upon a table before the dais in every one of his own imperial audience-halls, some of which have been despoiled by invaders from the West and been afterward acquired for the enrichment of our Collection of jade and other hard stones.

Jewelled Jades

In the classification of the Collection "jewelled jades" is the second subdivision of the worked jade of China. It includes carved objects of nephrite and jadeite inlaid or set with other precious and semi-precious stones, and jade mounted in gold or gilded metal for imperial presents and for personal ornaments. The latter class is represented by a gilded *ju-i* sceptre, No. 734, richly chased with floral scrolls and emblems, mounted with plaques of emerald-green jadeite carved in symbolical designs of long life and happiness; by a pendant, No. 732, of gray-green jadeite fashioned in the form of the fruit of the egg-plant; and by the magnificent set

of gold-mounted jewelry, No. 733, composed of a pendant, ear-rings, and bracelet of deep-green jadeite of Chinese workmanship, the rich lustrous tones and varied tints of which are perfectly shown in the colored plate in this volume which may be cited as a masterpiece in miniature of Prang's lithographic skill.

With regard to the class of inlaid jades, the Chinese work in this department is not so remarkable as the Indian. The Hindus, especially in the Mogul period, as we shall see presently, have appreciated in the highest degree the pellucid depth and soft sheen of certain white and green jades which made them such an effective background for the display of the most brilliant precious stones, such as the diamond, ruby, sapphire, and occasionally the pearl. Their method is to chase the surface of the jade with floral patterns and hammer in fine gold, turning over the edge of the gold to fasten the jewels, which are generally cut *en cabochon*, more rarely split into plates. Chinese jewelling consists generally, on the other hand, of the application of the jewels in the form of fruit, flowers, or human or other figures, cut out in full outline, and fixed on the surface of the jade by means of cement. The stones most frequently used are the amethyst, garnet and ruby, the turquoise, lapis lazuli, and carnelian. The miniature brush-holder of olive-green nephrite, No. 741, is inlaid with emblems of longevity and happiness, carved in lapis lazuli, coral, agate, quartz, mother-of-pearl, and stained ivory. There are two imperial jade-handled knives studded with jewels, Nos. 735 and 736, in the series, the second of which has already been referred to on account of its interesting inscription written by the Emperor Ch'ien-lung in the year 1744.

The oldest and most characteristic example of the jewelled class is the carved screen, No. 731, which has been illustrated by the artist Li in original water-colors for this work. In this the three figures of the Taoist triad, the star-gods of happiness, rank, and longevity, cut out in white jade, are mounted upon a circular plaque of spinach-green nephrite, the borders of which are incised, in open fretwork, with a medley of Buddhist and Taoist symbols peculiar to the later years of the Ming dynasty. The details of the central picture have been filled in with other stones shaped for the purpose. The gnarled trunk of the pomegranate, and the branches which make a canopy for the three figures, are of a stained grayish-brown nephrite; the leaves are of green jadeite of varied tint; the fruit of stained jadeite filled with seeds of spinel and garnet. The bats, emblems of the god of happiness, are of ruby and hyacinth rose-quartz; a branch of coral, the symbol of rank, is made of natural coral; the magic fungus of longevity is tipped with a ruby head. The rocky ground is sculptured in lapis lazuli of mottled tone, and the cactus plants growing upon it are outlined in turquoise of pale-greenish tint. The general artistic effect of this industrious combination of heterogeneous materials is, it must be confessed, more quaint than beautiful. It is of more interest from the light it throws on some of the mythological motives which pervade Chinese glyptic art.

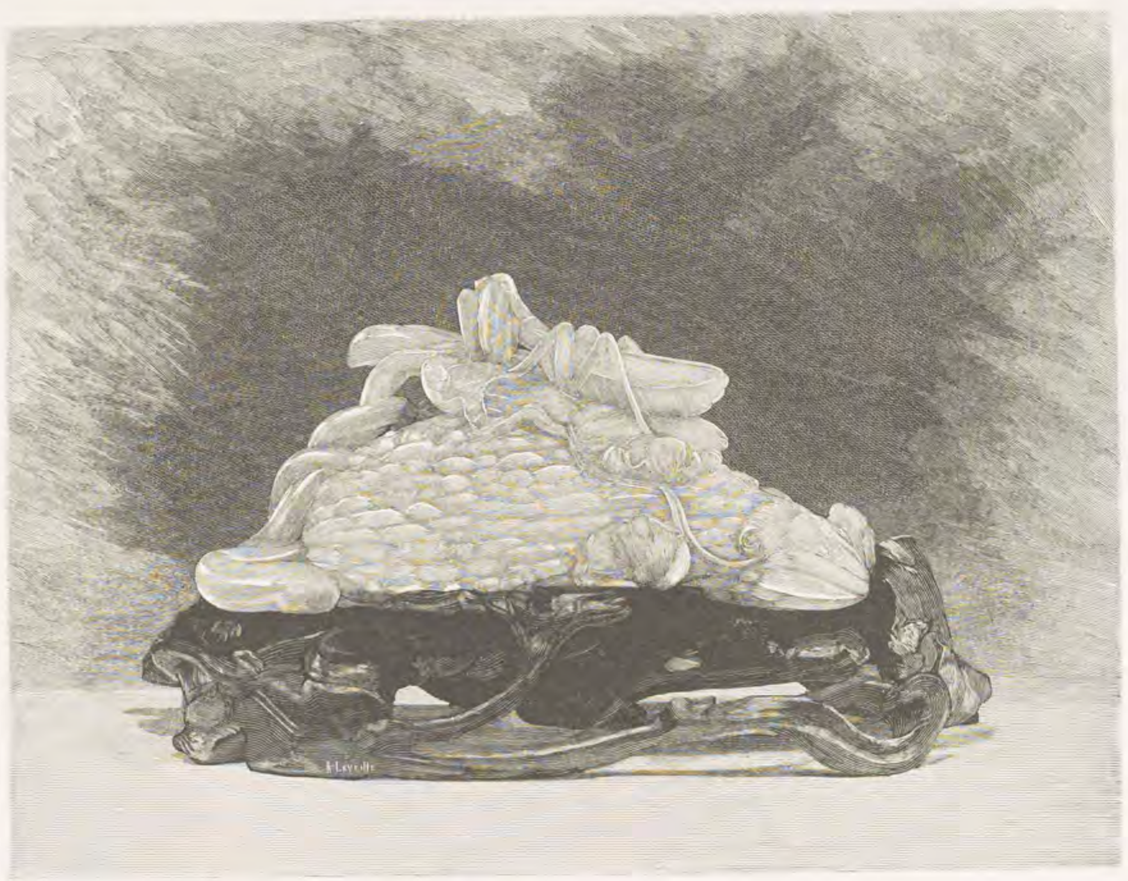
Jade Flowers and Fruit

Our third and last subdivision of the worked jade of China comprises a collection of composite creations peculiar to that country, representing flowers and fruit modelled in jade and other stones. The fruit is intended to be displayed on the altar of a sacrificial temple or placed upon the sideboard of a luxurious interior; the flowers usually stand in pairs of pots on the table of a reception-room, and make a brave show in the public procession of bridal gifts, which are always carried by bearers through the streets of a Chinese city before a wedding. The Taoist paradise on the slopes of the K'un Lun Mountains is traditionally supposed to be filled with trees bearing jade leaves and jewelled flowers; and T'ang, in his "Discourse," has quoted an old life of the Emperor Wu Ti of the Han dynasty, who flourished a century before the Christian era, relating how he built a sacred temple devoted to the Taoist cult, and erected in the front court trees of jade with branches made of red coral, leaves of green jade, and flowers and seeds, both blue and red, wrought in precious stones hollowed out in the middle like little bells, tinkling as they hung. The same author, in another part of his article, refers to the elaborate pots of jade flowers used in the decoration of a guest-room, for which a pretentious host will have a different pair provided for each of the four seasons of the year, and filled with appropriate flowers.

A typical pair of round dishes filled with fruit is exhibited under Nos. 745 and 746. The dishes are carved out of white jadeite with grayish tint, veined and clouded with light emerald-green. The fruit and flowers

with which they are filled are piled upon a flat base plastered with the turquoise-tinted plumes of the kingfisher, and consist of branches of peaches, apples, *lichi* fruit, and Buddha's-hand citron, together with flowers blossoming on the same stems, all modelled in white nephrite and amethyst, with the leaves carved out of moss-green nephrite.

A characteristic pair of pots of artificial flowers are Nos. 743 and 744, of which the second, illustrated in colors in this volume, will give a fair idea of the rest. The round dish of mottled olive-green nephrite mounted upon three feet of scrolled outline is filled with some material covered with a layer of red coral grains, from which projects a blue rock colored to imitate lapis lazuli. Three small plants with gold leaves, like violets, are growing out of the coral-strewn ground, and another plant stands up, on the right, with lanceolate leaves of mottled yellow and green precious serpentine and berries of red coral. The large flowering shrub is a chrysanthemum, displaying flowers of different colors grafted upon the same plant in Chinese fashion, and a rich foliage of mottled-green nephrite. The four white blossoms have the florets carved out of white jade with a circlet of gold stamens and a coral bead in the centre; there are three red flowers of coral and gold, and a fourth with a pearl in the middle, and a single yellow blossom with florets carved out of amber tipped with a red coral bead. The companion dish of artificial flowers, No. 743, contains a rosebush with flowers composed of petals of red coral, each one tipped with a pearl, within a circlet of gold stamens, buds of pink ground-glass with a mat surface, and leaves carved out of thin plates of mottled-green jade. It has underneath it the same blue rock and gold-leaved violets, with an anomalous six-petalled orchid having flowers with five petals of white nephrite and a sixth of red coral tipped with pearls.



No. 546. CARVING OF "A BITTER GOURD." CH'IEN-LUNG (1736-95).

The pot of artificial flowers No. 742 is especially remarkable for the naturalistic finish of the leaf-carving. It contains a clump of coral berries with large leaves of green nephrite overshadowing three blossoming shrubs,—a rose with flowers of red carnelian, buds of pink quartz, and leaves of green jade; a hibiscus with flowers of amethyst and amber, and leaves of green jade; and a chrysanthemum with blossoms of white jade and red coral, and leaves of green jade,—the intervals being filled in with gold-leaved violets and polyporus fungi, modelled in amber, growing beside bunches of gold-leaved grass.

2. INDIA

The general conclusion of scientific investigators is that there is little or no true jade to be found (*in situ*) in India, although Mr. Mallet's report upon the subject refers to its existence in one or two localities in the Northwest Provinces. The observations of the Geological Survey are summed up in a note on jade in the Geological Survey Manual, Vol. III, p. 516: "In the Mirzapur District in N. W. Provinces hornblende rock west of Dumrahur passes into the condition of jade. Bands of one foot and more thickness are interbedded with mica-schist. Olive-green jade occurs northwest of Kisari in the N. W. Provinces, and there is also jade associated with the corundum of Pipra." But there is no record of mining at any of these localities, and it is probable that most of the material used in objects of Indian workmanship was obtained from some foreign source. The beautifully white translucent jade of which vases, bowls, cups, and other artistic objects were

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No. 744

DISH WITH PLANTS

(*P'en Ching*)

Ch'ien-lung (1736–95)

Nephrite


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carved and often inlaid with jewels during the Mogul period would seem to have been brought from Turkistan. The mines in the K'un Lun Mountains and the beds of the rivers running from this range appear, consequently, to have been the chief source from which India as well as China has always derived its supply of fine white jade. The country, in fact, formed part of the dominions of the Moguls during the whole time that they were invading and finally conquering India, and they would have had no difficulty in obtaining from it an ample supply of nephrite.

The Mongols seem always to have shown a high appreciation of jade, which is found in their original country. Down to the present day, kindred tribes living in the neighborhood of Lake Baikal are described as fond of wearing amulets, rings, and other ornaments of the green jade which is produced in this territory. The famous Genghis Khan, the founder of the powerful Mongolian dynasty which subsequently ruled over China, Persia, and India, is said to have discovered, at the outset of his career, a tablet of green jade inscribed with a decree from heaven conferring upon him the dominion of the world. A more tangible relic is the great monolith of dark-green nephrite on the tomb of his descendant, the great Timur, or Tamerlane,[1] which is still to be seen in the Gur-Emir mosque at Samarkand. A small piece broken off from the jade of this tomb has found its way from the Fischer Collection at Freiburg to the Museum of Natural History in New York, and is placed in the same glass case as the Mogul mace-head of jade to be referred to presently. A tiny fragment taken from the museum piece of Tamerlane's tombstone is in the Collection, No. 77, and is described in Volume II.

Tamerlane died in the year 1405. In 1526 Sultan Baber, his descendant, a direct descendant also of Genghis Khan, overthrew the last of the Afghan kings at Panipat and founded in India the Mogul empire. The whole of the territory was lost again afterward, but recovered shortly before the accession, in 1556, of his grandson Akbar, in whose reign the empire was finally established, embracing Cabul, Candahar, all Hindustan, and a portion of the Deccan. He was succeeded by his son Jehanghir (1605–1627), who received in 1615 an embassy from England despatched by James I under the conduct of Sir Thomas Roe. Under his successor, Shah Jehan (1627–1664), the Mogul empire reached its zenith. Many grand buildings testify to the magnificence and taste of this great ruler—among others, the Taj Mahal at Agra. He was succeeded by his son Aurangzeb (1658–1707), who dethroned his father and kept him a prisoner for seven years till his death in 1664. The imperial revenue in his reign amounted to £43,500,000 sterling, but the decline of the Mogul empire dates from this period; and it was only thirty-two years after his death that Nadir Shah of Persia invaded India, sacked Delhi, and carried off plunder estimated at fifty millions sterling.

No. 476. FLATTENED WATER-JAR. YUNG-CHÊNG (1723-35).

Jade was not, as far as we know, used for art work in India before the Mogul period. To quote a letter from Professor Maskelyne of the British Museum, written to "The Times," December 30, 1879, and reprinted in Schliemann's "Ilios," 1881 (page 498, note): "The introduction of jade, or at least its use as a material for artistic workmanship in India, dates almost from yesterday, since it belongs to the time of the early Mogul Emperors of Delhi. The magnificent son of Akbar, Jehanghir, and his son Shah Jehan seem to have taken pleasure in jade cups and ornaments, and the art of inlaid work

[1] This was first figured by Fischer, the great authority on jade, in the Arch. f. Anthr., 1880, XII, p. 469. It has been more fully described by Beck and Muschketow in the Transactions of the Imp. Miner. Soc. of St. Petersburg, 1882, XVIII, 38–49, Pl. II, III. They give an analysis, and describe it as nearly two metres — *i. e.*, about two yards — long, of deep-green nephrite, with a specific gravity of 2.926, and derived, in their opinion, from a Turkistan source near Khotan.

that found such exquisite expression in the Taj Mahal was copied under their munificent auspices in the most precious materials, rubies and diamonds and other precious stones being inlaid in jade of various colors, which was cut in delicate openwork and adorned with enamels, in the production of which India is still unrivalled. The collection of these beautiful productions of Indian art contained in the India Museum is the finest ever brought together. It was purchased at a suggestion from myself, a selection having been made by the late Sir Digby Wyatt and me from a unique collection of jade vessels of all sorts, formed at great expense and trouble by the late Colonel Charles Seaton Guthrie."

No. 775. JEWELLED JAR AND COVER. INDIA (SEVENTEENTH CENTURY).

From this same collection came one at least of the series of jewelled jades illustrated in this volume, the dagger-handle of sage-green jade, No. 778, carved with a horse's head and inlaid with rubies and emeralds. The author of "Industrial Arts of India," 1894, Dr. G. C. M. Birdwood, figures two of the finest of the pieces in the India Museum. He says of them (page 268): "The old Delhi work in cut and gem-encrusted jade is priceless. The Chinese had cut jade for ages, but never ornamented it except by sculpture; but when it was introduced into India, the native jewellers, with their quick eye for color, at once saw what a perfect ground it afforded for mounting precious stones, and they were the first to encrust them on jade. The India Museum possesses the choicest and grandest specimens of this work known, of the best Mogul period (Plates 56 and 57). They were first exhibited at the Paris Exhibition of 1867." One of the bowls which are now to be seen in the South Kensington Museum is said to have cost the Mogul emperors Jehanghir, Shah Jehan, and Aurangzeb, in wages paid to three generations of the same family of artists, the sum of £6000 sterling. It was for the Crystal Palace Exhibition of 1851 that the first collection of jewelled jades was made and sent to Europe by the Indian government, and the most important of the pieces exhibited there, which is now in the Collection, is beautifully illustrated in this volume, No. 768, a large oval box of white jade, which has the cover decorated with a charming floral design of gold-inlaid work set with fifty-eight large rubies and emeralds.

One of the earliest known examples of this work is the staff which is described in the artistic work on "Jeypore Enamels" by Colonel Jacobs and Mr. Hendley, 1886 (page 56): "The most ancient specimen of Indian enamel now in existence is probably the crutch staff of Maharaja Man Singh, of Jeypore, one of the greatest of the chiefs who adorned the court of Akbar at the close of the sixteenth century. This staff, upon which the Maharaja leaned when standing before the throne of the Emperor, is fifty-two inches in length, and is composed of thirty-three cylinders of gold arranged in a central core of strong copper, the whole being surmounted by a crutch of light-green jade set with gems. Each of the thirty-two upper cylinders is painted in enamel with figures of animals, landscapes, and flowers. This splendid specimen of ancient art is decidedly Turanian in the boldness of its design, in the nature of some of the subjects, as for example the lotus flowers and leaves, and in the daring manner in which the primary colors are employed to produce a harmonious whole. We must also remember that the owner of this most venerable piece of enamel was one of the pillars of the throne of a true Turanian sovereign, a most munificent patron of the arts, alike of his new home in India and of his ancestral dominions in Central Asia."

The description is quoted in full on account of the light it throws on the introduction of Turanian art into India at this period. It is stated, too, in the "Ain-i-Akbari," or "Institutes of Akbar," by Abul Fazl, the state historian of his reign, that Akbar did his utmost to attract the best artists from all parts of the world. These might well have included Chinese artists for the new work in jade, a special province of Chinese art long

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No. 777

JEWELLED BOX AND TRAY

India

Seventeenth Century

Nephrite

No. 768

JEWELLED BOX

India

Seventeenth Century

Nephrite

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before. We notice, indeed, a certain resemblance to Chinese forms in the shapes of some of the vessels—in the prevalence of the gourd, single and double, for example, which might be accounted for in this way.

It was not till the next century, however, that the existence of this new school of art work in jade became known to the people of China itself, after their conquest of Eastern Turkistan had opened up the way to India. The Emperor of China, Ch'ien-lung, in his verse written in 1770 and engraved on the remarkable Indian bowl, No. 762, which must have been taken out of the Summer Palace at Yuan Ming Yuan, expresses his surprise that such jade should come not only as tribute from Yurangkásh in Khotan, which had been for long centuries past the chief source of jade for China, but be brought also by merchants from far-away India. The author of the "Hsi yü wên chien lu," a description of the new dominion of Chinese Turkistan published at Peking in 1777, a Manchu general who had been stationed there in command of the army, alludes to the surprising fact that artistic objects of jade were cleverly carved in India and brought overland through the passes of the Himalayas from Lahore (which he writes *Lahurh*) to Kashgar. This was the route, no doubt, by which our piece, which has its history written upon it in the imperial autograph, reached the celestial capital. A number of similar jade objects of Indian workmanship brought to Peking during the eighteenth century, and also subsequently inscribed with verses by the emperor Ch'ien-lung, are described in the "Hsi yü t'ou chih," the principal geographical work on Chinese Turkistan.

After these specimens of Indian work had been brought to their own country in the way we have indicated, the Chinese, struck by their artistic value, at once proceeded to imitate them, copying both the forms and the decorative details. Chinese connoisseurs of jade in the present day at Peking distinguish such pieces as belonging to what they call *Hsi-Fan Tso*, or *Indu Tso*, literally "Indian Manufacture," although they should say, rather, "Indian School." It is not always, however, so easy to decide positively in every case whether we have an original or only a copy before us, although the hand of the Chinese craftsman will generally be betrayed by some detail in his handiwork. A typical example of the "Indian School" in Chinese work is presented in the quadrangular vase of white jade, No. 624, shown in the accompanying illustration. The elegant floral designs, composed of graceful leafy scrolls and highly conventionalized flowers, which cover the sides of the vase, the palmetto bands round the neck and foot, and its open-scroll handles and leafy knob, are of marked Indian style, while the comparative heaviness of the form and the smaller details of the decoration betray the Chinese workman.

No. 624. QUADRANGULAR VASE. CH'IEN-LUNG (1736-95).

The well-known historian and philosophical writer of the period of Louis XV, François Bernier, spent twelve years of the earlier part of his life in India, eight of them at Delhi as court physician to the emperor Aurangzeb, and was commonly called *le Mogol* to distinguish him from others of the same name. He returned to Europe in 1670 and published many books, some of which were translated into English and other languages, and is a chief authority for Indian history of the time. In his "Voyages," published in Amsterdam in 1699, and which has been already quoted in the Introduction, he refers to jade, under the name *yascen*, as considered of great value and highly esteemed in India, and used there for carving into bowls and cups, and he describes it correctly as a stone of great hardness.

Much of the finest artistic work of the Mogul period must have been carried off during the sack of Delhi in

1739, when the immense imperial gold throne inlaid with enamels was taken away by Nadir Shah with the rest of the Mogul regalia to Persia. From this country many pieces have found their way westward, and Dr. A. B. Meyer of Dresden, one of the latest authorities on jade, is even inclined to attribute some of them to Persian workmanship. One of the objects, the jade head of a ceremonial mace which belonged once to the Mogul regalia, is exhibited in the Museum of Natural History in New York City. It is as large as a small orange, with a fluted surface honeycombed with holes, and was purchased in Persia from one of the descendants of Nadir Shah. The family, living in Teheran and reduced to poverty, had previously picked out the large jewels, one hundred and sixty-nine in number, which must have been once set in the holes, and were only too pleased to find a purchaser for the unsightly but historically interesting object which the precious stones had formerly adorned. The original effect may be imagined from a glance at the ceremonial sceptre in the Collection, No. 784, though its form is different. This last is a sceptre fashioned in the form of a mace, with a head tipped with a small fir cone composed of five radiating upright wing-like blades of sage-green nephrite chased with floral scrolls inlaid with gold and set with a hundred garnets, and a silver-gilt handle topped by a spiral rod of light-gray nephrite inserted into a hilt of the same material of greenish-black color.

It is difficult to obtain any detailed description of modern jewelled work in jade as actually carried on in India. The native artificers are highly secretive and unwilling to disclose to strangers the methods of their art, which seems to be worked on a small scale only, on technical principles handed down in particular families of workmen. More important objects are produced, however, in response to a special stimulus, like the three pieces which were sent to the Exhibition of 1851 and were afterward purchased for the Indian Museum in London, where they are labelled as "Indian (Lahore). Modern." They include a vase of white jade $4\frac{1}{4}$ inches high, inlaid with gold, rubies, and emeralds, purchased for £20; a box of white jade fluted, with cover inlaid with gold, rubies, and emeralds, height $1\frac{1}{8}$ inches, length $2\frac{1}{8}$ inches, width $1\frac{7}{8}$ inches, £24; and a box of green jade, of oblong octagonal form, with cover inlaid with gold and rubies, height $2\frac{3}{4}$ inches, length 6 inches, width $4\frac{3}{8}$ inches, bought for £42.

Indian jade is well represented in the Collection by a long series of artistic objects, some plainly carved, others inlaid with jewels, which will be described at length in the next volume. They include vases of varied form, jars with covers, small bottles, and rose-water sprinklers; dishes and plates, round boxes, ring-cases, rouge-pots with fluted trays and fretwork mirror frames; mace-like sceptres, dagger-hilts, sword-guards, and archers' thumb-rings; girdle-clasps, armlets, finger-rings, pendants, and other ornaments, among which a jewelled butterfly is conspicuous. This jewelled butterfly, No. 781, which is illustrated in colored lithography with the Kleczkowsky jewels from China, has its wings modelled in plates of emerald-green jadeite, and is remarkable for being the only specimen of jadeite in the whole Indian series. Everything else is nephrite, ranging in color from pearl-white and white with faintest tinge of green through many intermediate shades to tones of deepest green that became in one case almost black. Some of the purer white shades are especially characteristic, having the merest suggestion of a greenish tint, while the body has somewhat the aspect of milky rice when held up to the light, and is so translucent that print can be easily read through it. This acquires a peculiarly soft sheen when polished, and forms an admirable background for the display of inlaid jewels. Another shade more often found in Indian work than elsewhere is a more or less translucent sage-green. The occurrence of the above two kinds of jade seems to indicate some local sources of supply hitherto unknown; but something of the effect may, perhaps, be due to their methods of working the material.

The two colored plates in this volume will give a faint idea of the gorgeous brilliancy and, withal, general harmony of the jewelled decoration. A more effective ground for ruby flowers and emerald leaves could hardly be imagined than the pale-green surface of the rounded oval box, No. 768, in which the rare jewels are embedded,—unless it be the pellucid pearly-white surface of the little jewelled box with four compartments, No. 777, which is illustrated on the same plate,—or, maybe, the light sage-green ground of the four-lobed tray on which the little jewelled box stands.

Another colored plate exhibits a further selection of Indian jewelled jades of the seventeenth century. The inlaid bottle in the centre, No. 779, a rose-water sprinkler of dark sage-green nephrite set round the

No. 781

JEWELLED BUTTERFLY

India

Eighteenth Century

Jadeite

No. 733

GOLD-MOUNTED JEWELRY

(*Shou Shih*)

Ch'ien-lung (1736–95)

Jadeite


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swelling shoulder with leaves of fluted white jade mounted in gold, is decorated in silver inlay with feathery sprays of foliage. Of the two dagger-handles, one, No. 778, carved in the shape of a horse's head, is of sage-green tint with a patch of dead-oak-leaf, cunningly utilized in the design; the other, No. 769, of curved outline, is white faintly tinged with green and encrusted with more than a hundred diamonds, emeralds, and rubies. The jewelled bowl, No. 772, once belonged to Bahadur Shah of Delhi, and the jewelled armlet, No. 770, one of a pair, is an example of the Jeypore enamelling which has already been cursorily referred to, being decorated with dragons' heads in green, red, and blue enamels set with precious stones.

No. 618. SMALL QUADRANGULAR VASE. CH'IEN-LUNG (1736-95).

While jewelled jade is a striking type of the luxurious magnificence of the Mogul emperors, there is something about the plainly sculptured jade of the period which appeals more keenly to the artistic eye. The graceful lines of the form and the perfect finish of the workmanship of the period combine to give a vivid impression of the intrinsic beauty of the material. The little bowl, No. 756, for example, with fluted sides of egg-shell thinness and delicate spiral handles, is not only of charming form, but is also described as unsurpassed for purity of material and color, beauty of texture, and high polish. The vase, No. 759, again, is just as remarkable for its grace and elegance, being freely fashioned in floral form and appropriately decorated with floral details, and having rings hung upon looped handles of chrysanthemum buds.

The chrysanthemum is a favorite motive of the Indian glyptic artist, as proved by many other bowls and dishes in the Collection, such as the bowl, No. 762, illustrated in this volume, which is conventionally modelled in this form and derives all its decorative details from the same flower, its buds forming two loop-handles and a ring of leaves an ornamental border in low relief round the foot of the fluted bowl.

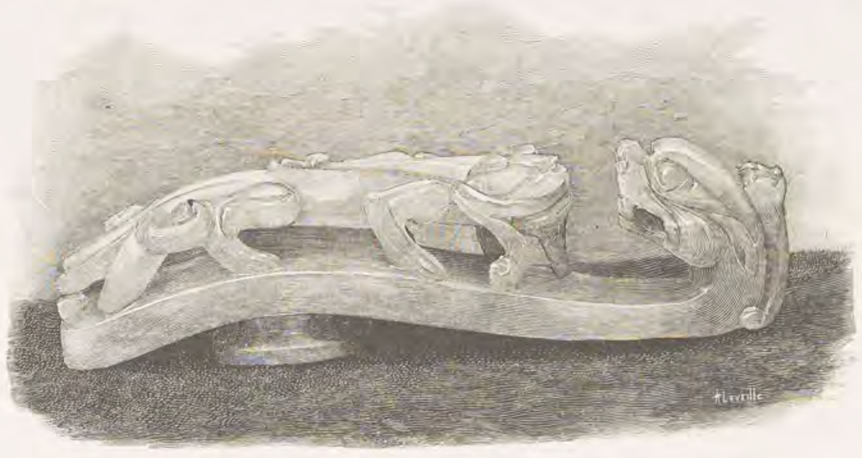
The mirror-frame, No. 764, of dark sage-green nephrite, delicately carved as it is in openwork with intricate floral patterns, may finally be cited as an example of glyptic work in jade executed in the style of the elaborate stone fretwork of the Mogul period as seen on the Taj Mahal and other architectural monuments.

3. ANNAM

From India we pass to Indo-China and to the old empire of Annam, which now forms part of the French dominions in that country. The pieces of jade from Annam in the Collection are few in number, but of exceptional importance as relics of the old native dynasty. They are: an imperial girdle studded with eighteen jewelled medallions of brilliant-green jadeite set in gold; an elaborately mounted screen of pale-green jadeite mottled with grayish and purplish clouds, engraved with a landscape of a picturesque mountain retreat filled in with gold; and a portable ink-pallet of light-green nephrite faintly tinged with sage-green. They are reported to have been brought to Paris from Annam shortly after the occupation by the French forces of Hué, the capital, in the year 1887, and are supposed to have been stolen from the palace in spite of strict prohibitions against looting.

The imperial girdle, No. 796, illustrated in this volume, is a belt of ribbed and brocaded cloth of gold, and the medallions with which it is studded are carved with diverse designs of imperial dragons in the midst of scrolled clouds. The gold frames in which they are set are overlaid with a delicate appliqué design of floral

scrolls and symbols and have their free rims mounted with pearls. The girdle is interesting because it shows the ancient style of the court dress of China before the Manchu conquest in 1644, when girdles of this kind were worn set with carved plaques of jade, of which several specimens will be described in the Chinese part of the Collection.



No. 374. GIRDLE-BUCKLE. MING DYNASTY (1368–1644).

The screen, No. 797, which is illustrated and described at some length in Volume II, is remarkable for the large size of the slab of jadeite, as well as for the sumptuous but barbaric richness of the mounting, which is inlaid with gold, ivory, nephrite, kingfisher's plumes and bright enamels, and set with many kinds of precious stones,—a perfect microcosm of mythological symbols culled from Chinese sources.

The ink-pallet, No. 798, which is shaped to be held in the hand and carved with felicitous symbols, is inclosed in a box of repoussé gold chased with flowers and butterflies, which is engraved on the top with an inscription of four stanzas of rhyming verse composed by the emperor Gya-lung, who reigned from 1802 to 1819. It is accompanied by a water-horn which is mounted in gold and strung with silken tassels for suspension from the girdle, being intended to carry a supply of water for the pallet. The horn is engraved "Variegated dragon's horn" in large gilded characters, and the gold mounting is embossed with imperial symbols. The weight and "touch" of the gold are indicated in both cases by dotted characters lightly incised under the neck of the dragon and on the bottom of the gold box which holds the jade pallet.

4. EUROPE AND NEW ZEALAND

Nineteenth-century Jades

Although jade is found *in situ* in several localities in Central Europe, and prehistoric weapons and implements of jadeite and nephrite have been dug up from the remains of lake-dwellings in Switzerland, from ancient tombs in Brittany, and other parts of France and southern Germany, and, more recently, from the ruins of neolithic settlements in Crete and the shores of the Mediterranean, jade appears never to have been employed there as a material for artistic work. Consequently all the pieces in the Collection classified under this heading belong to the latter half of the nineteenth century. Most of them have been specially carved to show the capabilities of the several varieties of jade as media for fine lapidary work. Seven of the pieces in the Collection were executed at Paris in private lapidary workshops; the remaining three come from the imperial glyptic works at St. Petersburg, where Siberian jade is fashioned into vases and other artistic objects, modelled in classical lines, a magnificent selection of which was exhibited, by command of the Czar, at the Paris Exposition of 1900.

Among the pieces of modern French work the cleverly executed statuette of the Venus de Milo, No. 799, is a striking example of the lavender jadeite, lightly flecked with white, which is supposed to come from the southeastern corner of Tibet. The profile portrait of the writer, No. 800, has been carved in relief upon a fine piece of New Zealand nephrite, as well as the bonbonnière, No. 801, of Louis XV style; the armlet, No. 804, of darker pear-leaf green; and the little scent-bottle, No. 803, of spinach-green. The finest specimen of modern work in jade is the elaborate paper-knife, No. 802, of brilliant seaweed-green, which was cut in Paris out of a large water-worn block of nephrite sent from New Zealand to England for the Colonial Exhibition of 1886, the boulder, some three feet in diameter, having come from one of the lakes of Te Wahi Punamu, the chief jade-producing district. The finely polished rectangular bar, No. 805, of remarkably translucent pear-leaf-green nephrite, also from New Zealand, is notable for the unctuous lustre of its polished surface, a peculiar characteristic of the material.

The three objects of Russian workmanship exhibit the brightly variegated shades of green, flecked with

tiny specks of black due to inclusions of chromic iron, which distinguish Siberian nephrite. The plain shallow bowl, No. 806, is most brilliantly polished and remarkably sonorous. The miniature mammoth, No. 807, carved from a boulder of nephrite from the Onot River in Siberia, shaded in rich oily greens of varied tone, comes from the Paris Exposition of 1900. Another design of appropriate character is that of the paper-weight, No. 808, which is fashioned in the shape of a Russian two-*funt* weight and marked with the year 1899, when it was made at St. Petersburg from Siberian nephrite.

The older aboriginal implements and weapons of New Zealand, New Caledonia, and New Guinea in the Collection have been included among the archæological specimens, and there remain for notice here only a few ornaments of more modern manufacture, which are numbered 809–812. They are all of nephrite and include an ear-drop (*kuru*) and a pendant of beautifully translucent green tint, a pendant or ear-drop of spinach-green, and a large claw-shaped pendant (*kapehu*) of dark spinach-green color. These ear-drops were much prized by the Maoris, and handed down from generation to generation, so that the history of some could be traced back by them for several hundreds of years. The native name is generally literally translated "greenstone," and we are told that the highest term of endearment a lover can apply to his sweetheart is *Kuru-tongarewa* —that is, "Superb Greenstone Ear-drop."

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VASE AND COVER

(*Kai P'ing*)

K'ang-hsi (1662–1722)

Nephrite

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Previous to Han Dynasty

Nephrite

No. 322

ORNAMENTED CELT

(*Hua Chan*)

Previous to Han Dynasty

Nephrite

No. 293

HATCHET

(*Yao-chan*)

Previous to Han Dynasty

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